

FORTY-FOURTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

University of Kentucky
LEXINGTON, KENTUCKY

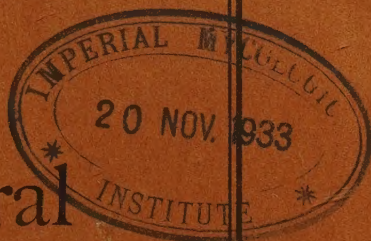


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UNIVERSITY OF KENTUCKY

For the Year 1931



Part I.

Report of the Director
Meteorological Summaries

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LEXINGTON, KENTUCKY

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LETTER OF TRANSMITTAL

To His Excellency, Hon. Ruby Laffoon, Governor of Kentucky.

Sir: In accordance with an act of Congress, approved March 2, 1887, entitled, "An Act to establish Agricultural Experiment Stations, in connection with the Agricultural Colleges established in the several states under the provisions of an act approved July 2, 1862, and under the acts supplementary thereto," and of the act of the Legislature of the State of Kentucky, approved February 20, 1888, entitled, "An Act to accept the provisions of an act passed by the Congress of the United States, approved March 2, 1887, for the establishment and maintenance of Agricultural Experiment Stations in connection with Agricultural Colleges established by the several states and territories under an act of Congress approved July 2, 1862," I herewith submit the Forty-Fourth Annual Report of the Kentucky Agricultural Experiment Station.

Very respectfully,

THOMAS P. COOPER, *Director.*

January 1, 1932.

ANNUAL REPORT
of the
DIRECTOR OF THE KENTUCKY
AGRICULTURAL EXPERIMENT STATION
For the Year 1931

The work of the Experiment Station is divided into three principal groups: that of research, which reveals new facts; that of service, which provides communities, civil units and groups with specialized information otherwise unavailable to them; that of administration of the various legislative acts designed to protect the consumer against misbranded products, such as feeds, fertilizers, nursery products, etc. Such a program of work reaches every part of the state. It affects, directly or indirectly, every home and contributes to the progress of the state.

The Experiment Station was established by act of congress "to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture and to promote scientific investigation and experiment respecting the principles and applications of agricultural science." Agricultural progress in the State of Kentucky has been influenced in no small way by the work of the Experiment Station. The results of its research and investigations are evident in improved farming practices. Since its organization, farmers in increasing numbers have consulted the staff of the Experiment Station and have utilized the results of its investigations. Requests for specific information have increased from year to year.

Kentucky farmers in many areas have been confronted with the problem of restoring soils depleted in fertility or with

maintaining the fertility of lands under cultivation. Early in the history of the Experiment Station, investigations toward this end were undertaken. It was found that the use of lime and phosphate in connection with a suitable crop rotation and the use of crop by-products would not only maintain productive soils, but restore depleted soils to a highly productive condition. Many thousands of farmers have adopted this method of soil maintenance and have found it relatively inexpensive and materially contributive to their profits.

For a number of years considerable attention has been devoted to research investigations concerning the occurrence, distribution and function of some of the less common elements in soils, plants and animals. It has been demonstrated that certain of the less common elements, including manganese, copper, zinc, boron, barium, iodine and bromine, are widely distributed in small amounts in the rocks and soils of Kentucky and that minute quantities of these elements have important functions in the economy of plants and animals. The Kentucky Agricultural Experiment Station is a pioneer in this field of agricultural research and the discoveries made here are proving to be of considerable practical importance in agriculture. The investigations conducted at the Kentucky Station are receiving noteworthy recognition in foreign countries.

Sterility of mares, frequently in individuals of great value, has always been a perplexing problem to many breeders. Ten years ago, investigations were organized to study the causes of sterility and to develop methods of control and prevention. As a result of the study, certain important causes were revealed and control methods established and proved in an experimental way. Many breeders have put into practical use the methods advocated by this institution and the horse breeders of England and European countries, as well as of the United States, look to the Kentucky Experiment Station for leadership in this particular field.

The disease of tobacco known as root-rot has caused much loss to growers. Breeding and selection have resulted in strains of white burley tobacco highly resistant to root-rot. The seeds

of these strains have been distributed to large numbers of farmers. In the study of tobacco diseases, it was found that mosaic is one of the causes of leaf of poor grade and reduced yields. A method of control has been developed that, if followed, practically eliminates this source of loss to the tobacco grower without any expense whatever.

The production of red clover, so important as a forage and soil-building crop, has diminished in many of the farming areas. It was commonly considered that the soil was "clover sick," or that other causes contributed to clover failures. The discovery has been made that the use of seed from unadapted varieties has caused a considerable proportion of the failures. The elimination of the use of foreign seed and the selection of outstanding local strains adapted to local conditions have given a new impetus to red clover production. This renewed production and the use of locally grown seed have increased the income of many farmers.

Many and varied investigations have been conducted in the field of animal and poultry feeding. It has been the purpose either to determine combinations of feeding stuffs that give a more economical product or to present, by means of comparative trials, the difference in product that may be obtained from changes in combinations of feeds. The results of these investigations have been of profit to feeders of beef cattle, sheep, swine, dairy cattle and poultry. They are largely responsible for the advance that has been made by the livestock feeder, the dairyman and the poultryman.

Extensive inquiries have been made in the various economic aspects of agriculture. Investigations to determine the most desirable utilization of land areas of the state are now in progress. These studies will result in information as to the areas that may most advantageously be used for agricultural production, forestry, jointly for agriculture and forestry, or for recreational areas. In recent years, much attention has been given to questions of price, cooperative organizations, pooling, the distribution of farm products and the various types of collective action possible to farmers. These studies

have established facts which enable the various cooperatives to act with greater certainty and with more accurate knowledge when problems confront them.

The illustrations cited represent but a small part of the researches and investigations of the Experiment Station. They are presented as a partial picture of the manner in which the investigations may be of benefit to the economic life and development of the state. A consideration of the work of the Experiment Station thruout its history shows its effectiveness as an aid to agricultural interests and that it has proved of great advantage to the farmer.

The physical plant of the Experiment Station has been increased by the construction of a beef-cattle barn and a pig-gery. These additions were greatly needed and will make work in these lines more effective. Many of the older frame buildings on the farm have become obsolete and require a large expenditure for maintenance and upkeep. A modern dairy barn is needed and the removal of some of the old frame buildings is advisable. Such improvements will be made when funds permit.

The Western Kentucky and the Robinson Substations are important adjuncts of the Experiment Station. They fill an important place in the agricultural progress of western and eastern Kentucky. The localization of work carries to farmers of these regions methods that they easily adopt into farming practice. Each substation is annually visited by large numbers of people, many of whom make the visit to obtain definite information or to study the work in progress with a view to forming their own conclusions as to its application to their individual farms.

Commercial feed and fertilizer control, the public service laboratories, the creamery license section and seed laboratories, have performed a large amount of service during the year. Demands for many of the services have increased to the extent that the present facilities of the staff and laboratories are over-taxed. These services are of direct aid and protection to the farmer, to many industries and to a very large group of citizens who are only indirectly interested in agriculture.

The varied activities of the Experiment Station for the year are presented briefly in this report. Results of work and detailed reports of research projects are issued from time to time in bulletins and circulars which are available upon request.

Agricultural Credit and Finance. Attention has been given to a study of the amounts, uses, costs and terms of credit on 600 farms selected in four sections of the state, representing different types of farming. A special effort has been made to discover the influence of such factors as size of farm, type of farming and farm organizations upon credit problems of farmers. Altho the analysis of the data has not been completed, several significant conclusions may be mentioned:

1. The average age of farmers was only slightly greater for those who operated non-mortgaged farms than those who had farms that were mortgaged, but the average tenure of the former was 24 years as compared with 12 years for the latter.
2. The rate at which mortgage indebtedness was retired on this group of farms was approximately equal to the rate of amortization of the federal land banks.
3. Farms whose chief source of income was from crops were more heavily indebted than farms where the chief reliance was on livestock. Mortgage indebtedness was found to be relatively greater on farms specializing in cash crops, whereas short-term credit was relatively more important on farms with much livestock.

Agricultural Prices. In conformity with the initial aim of this study, groundwork is being laid for the construction of agricultural indexes for Kentucky. Production, marketing and monthly price data for the various farm commodities are being assembled, classified and interpreted. Tabulation of tobacco marketing (quantities) and average prices up to 1930 by years and months has been completed. Such monthly prices as have been computed and published for other commodities by the United States Department of Agriculture have been tabulated, also carlot shipments of fruits and vegetables.

Farm Organization Studies. The study of farm organization and management by the analysis of farm business and individual enterprises was continued. The results provide a better understanding of the factors for profitable farming and economic production for the various farm enterprises and indicate the importance of a well-balanced farm business.

An analysis of the business of 47 typical farms in Bourbon County for the farm year 1929 showed average net earnings of \$1832 above interest on the total investment. A detailed comparison of the most profitable 10 farms and the least profitable 10 farms showed striking differences. Thus, the most profitable 10 farms netted their operators an average of \$4,545 as pay for their labor and management. The least profitable 10 farms paid nothing for the labor and management of their operators and failed by \$264 to pay 5 percent interest on the farm investment.

Other marked contrasts between the most profitable and least profitable farms were shown. The receipts per acre operated were \$31.10 for the most profitable farms as against \$22.68 for the least profitable. The total expenses per \$1.00 of receipts averages 62 cents for the most profitable farms, \$1.05 for the least profitable, and 74 cents for the average. Livestock returns per acre pastured averaged approximately \$19 for the most profitable farms and \$14 for the least profitable. The value of tobacco per acre averaged \$253 for the most profitable farms, \$183 for the least profitable, and \$225 for all. The yield per acre of tobacco averaged 1024 pounds on the most profitable farms, 939 pounds on the least profitable, and 988 pounds on all.

The farms were classified on the five factors of labor efficiency, receipts per acre, total acreage, rate of stocking and percentage which the tobacco acreage bore to the total acreage of other crops. Classification was also made according to the number of the five factors on which they were better than the average. Eight of the farms were strong in none or only one of the factors and gave labor incomes of minus \$212; twenty were strong in two of the factors and the labor incomes of their operators averaged \$490; seven were strong in three factors

and gave their operators labor incomes which averaged \$1109; seven were strong in 4 factors and returned labor incomes averaging \$2280; five were strong in all five factors and the labor incomes of their operators averaged \$3585.

The table presents some comparative data of investment and earnings on accounting farms in Taylor, Green and Adair Counties for the period, 1926-1930, inclusive. The net earnings and total receipts were lowest in 1930. This was due largely to the extreme drouth of that year. It is evident that net earnings vary from year to year as well as from farm to farm. In making plans for farming over a period of years, it is necessary to consider the possibility of drouth and low yields and incomes like the year 1930, as well as years of high yields and incomes like the year 1928.

**COMPARATIVE INVESTMENT AND EARNINGS ON FARMS IN
TAYLOR, GREEN AND ADAIR COUNTIES.**

Item	1926	1927	1928	1929	1930
Number of farms	163	156	110	87	56
Total acres operated	122	126	132	124	123
Total crop acres	53	53	59	54	54
Total investment, dollars	6884	7514	8044	7584	7232
Investment per acre, dollars	56	60	61	61	59
Total livestock receipts	980	1198	1220	1156	739
Total receipts per crop acre	33	36	37	40	28
Total receipts	1754	1907	2195	2172	1496
Total expenses (including interest on investment)	1065	1209	1314	1252	1412
Labor income	309	273	439	502	-269
Farm furnished products	380	425	442	418	353
Net earnings	689	698	881	920	84

Land Utilization In Marginal Areas. The analysis of the data of this study made in Laurel County furnishes a definite picture of the land and other resources of an area which is typical of many sections of Kentucky. Groupings made in

the analysis furnish a statistical measurement of conditions in the area. The study brought out strikingly the handicap caused by the small amount of available crop and pasture land per farm. Limited cropping area is attended by the serious overcropping of sloping land, the result being a still further shrinkage of the meager supply of suitable crop land and a reduction of the farm income to the point necessitating the supplementing of income from some outside source or the abandonment of the farm. These unfavorable conditions result in very meager incomes, as shown by the following classification of farms by size groups:

No. of farms	Size of farm	Operator's net cash income	
		Including outside sources	Excluding outside sources
		Av.	Av.
40	15 acres and under	\$352	\$15
86	16 to 30 acres	262	123
52	31 to 45 acres	327	157
25	over 45 acres	552	362
203	All groups	332	134

In addition to these net cash incomes, the family incomes are supplemented by what is consumed directly from the farm itself. The value of the family living of all the farm families averaged \$689, of which \$365 consisted of goods furnished by the farm direct, including food valued at \$308, use of dwelling \$45, and fuel about \$11.

The study furnished a delineation between agricultural and non-agricultural land. Broken topography, steep slopes and light soils unfit a large part of the land for agricultural use. The study leads to some significant conclusions relative to land utilization. These may be summarized as follows:

Farming in combination with the utilization of timber products from farm woodlots probably will continue to be the

principal type of land utilization for the indefinite future. A better coordination of agriculture, forestry and related industries and enterprises is needed.

Over a considerable portion of the area studied, the pressure of population has led to attempts to utilize land for crop production that is wholly unsuitable for that purpose. The result has been that many families are reduced to a bare subsistence and the opportunity to get this tends to decrease with progressive deterioration of the land. Under these conditions, a decrease in the pressure of population appears to be essential in the economy of the region.

An adequate income depends largely upon having a sufficient acreage of suitable cropping land, and the use of relatively intensive enterprises. When these conditions are met, farming compares favorably as a means of livelihood with occupations which include non-farming as a chief source of income. There is great need for more emphasis on the production of intensive crops and for employing more intensive methods on all crops grown. It is imperative that the maximum use be made of every acre of well-lying tillable land. Growing intensive crops reduces the acreage of cropped land necessary for providing an adequate living, and reduces the acreage of steep land which many operators, using less intensive crops and methods, feel compelled to cultivate.

The proper utilization of the land in any system of cropping must provide a sod cover for the land most of the time. It follows that grass- and roughage-eating livestock are necessary in the farm economy. Since feed prices are high, livestock, to be profitable, must be limited, as a rule, to the kinds and numbers that can be carried on home-grown grass and roughage, supplemented by limited quantities of purchased concentrates. Because of the small size of most of the farms and the relatively large amount of family labor in need of employment, dairy cattle fill the most important place as a livestock enterprise. Beef cattle and sheep offer an economic means for utilizing grass and hay land when labor, markets or other requisites for dairying are not available. Hogs do not fit well into a plan

of land utilization in this area and have no place further than furnishing the meat supply for the farm family and, to a limited extent, some fresh pork for sale locally. Poultry more profitably uses home-produced grain and dairy by-products than hogs.

Rural Community Organization. The object of this study is to discover forms, means and practices of effective community organization for social advantages in selected communities and also to determine the traits of effective community leaders. Types of organizations and clubs being studied include community improvement clubs, men's church clubs, women's church clubs, young people's organizations, better farming clubs, homemakers' clubs, and parent-teachers' associations. The study includes every organization which has operated within the last five years in three typical rural communities located in Boyle, Boone and Fayette counties. A meeting-by-meeting record is being kept by each organization, showing attendance by age groups, the nature of the program, and the participation by local and outside persons. The organization connections and participation of each member of the family are being analyzed for a representative sample of approximately one-fourth of the families in each community. Collection of the field data for two of the communities has been completed. One surprising fact brought out was the large number of organizations found, one of the communities having 34 organizations.

Economic and Social Study in Knott County. Knott County is typical of the more rugged area of the eastern Kentucky mountain region. Until recently it was one of the most isolated counties in the state. An analysis of the figures for 228 farm families, for which complete data for income and outgo were obtained for the year 1929, shows that only about 15 percent of the families obtained 75 percent or more of their operating receipts from farm enterprises. The 228 families operated farms averaging 113 acres, only 13 acres of which were in crops. The total investment averaged \$2,812; the land and improvements averaged \$2,432 in value, of which \$331 represented the value of the farm dwelling.

The total receipts of the farm operators averaged \$506, of which \$99 was obtained from the sale of crops, \$66 from the sale of livestock and livestock products, \$39 from standing timber, \$77 from farm work and team work done by the operator away from the farm, \$47 from oil, gas and coal leases, and \$178 from work done by the operator having no relation to the farm business. The farm expenses averaged \$215. The total value of the food, fuel, use of farm dwelling and other items of family living furnished by the farm averaged \$481. These figures show the relatively great importance of farm-furnished food and other perquisites. They also show the small part of the net-cash income contributed by strictly farming enterprises.

A 5-acre tract of young yellow poplar timber observed in the study shows the possibilities of the practice of forestry in this territory. The owner of this tract fenced the area against grazing, built a partial fire line around it, removed all species except the poplar, thinned the stand and pruned the trees up to a height of about 10 feet. Altho the thinning was not as intensive as it should have been, since a large number of defective trees were left, this stand is putting on a net increment of 478 board feet per acre per year as against an average for all such stands of 430 feet. Had the thinning been completed, it would probably have produced an annual increment of 600 board feet per acre. The thinning was done at odd times and at no cost other than the owner's labor.

Economic and Social Survey of the Southern Appalachian Mountains. This is a regional project involving 165 mountain counties, 34 of which are located in eastern Kentucky. This study was begun in July, in cooperation with the Bureau of Agricultural Economics and the experiment stations of West Virginia, Virginia and Tennessee.

The project involves the preparation of a series of maps that will show for the whole Southern Appalachian Region, the varied conditions of soil and topography in the different parts of the region; will divide the region into characteristic type areas on the basis of physical characteristics, the extent and character of farming, and the presence or absence of other

kinds of industries; and will show for each type area the conditions and tendencies with regard to such important subjects as amount and composition of population, types of farming, forest industries, other classes of industry, market and transport facilities, social institutions and education.

The Motor Truck in Transporting Livestock. The trucking of livestock has increased rapidly in Kentucky during the last five years. Of the 331,214 head of livestock received at Cincinnati from 71 Kentucky counties in 1930, 34 percent were delivered by motor truck. At Louisville the receipts by truck from 53 Kentucky counties for the year were 227,500 head or 67.01 percent of total receipts. From January 1 to November 11, 1931, truck receipts of livestock at Evansville were 109,816 from 20 Kentucky counties. At Cincinnati, 96.2 percent of all livestock received from Kentucky by truck was transported less than 60 miles, the bulk coming from within 45 miles of the market. The bulk of the livestock trucked to Louisville originated in a belt located from 20 to 60 miles distant from the market, and at Evansville, 92 percent of the truck receipts from Kentucky came from within a radius of 60 miles. There was very little overlapping in the territories served by Cincinnati, Louisville and Evansville. In fact, there was a sharp demarcation between the areas of these markets.

There were important variations in the percentage of receipts trucked into Cincinnati and Louisville. For example, truck receipts of cattle at Louisville amounted to 54 percent of the total cattle receipts, while at Cincinnati only 17 percent of the cattle were delivered by truck. A similar situation occurred with hogs, for 65 percent of all hogs at Louisville were received by truck while only 20 percent were so received at Cincinnati.

The advantages of transporting livestock to market by motor truck, as given by the farmers, may be summarized in the order of their importance as: 1. Dispatch. 2. Convenience. 3. Low cost of service. 4. Additional market outlets furnished for livestock. 5. Livestock producers enabled to visit the market often and get a better understanding of market conditions and requirements.

Many farmers considered that the service rendered by motor trucks could be greatly improved if adjustments could be made in equipment used in trucking and protection of livestock enroute to market; business methods of truck operators, practices of handling livestock enroute to market; method of charging for services; and condition of roads.

The services rendered farmers by truck operators varied somewhat in the different market territories, depending on the extent to which trucking had been developed within the territory. The services rendered by truckers in the Cincinnati territory were more numerous and more varied than in either of the other territories studied. Practically every farm in the territory south of Cincinnati was on a regular truck route, which was covered at least twice a week, sometimes daily. In this territory, truckers have developed the back haul to a much greater extent than in other districts and many farmers now depend upon the truck driver to purchase and deliver to the farm, groceries, feed, coal, machinery, machinery repairs, fencing, roofing, etc. Often, practically all the farm and home supplies are purchased thru truck drivers.

Rates charged for trucking show considerable variation. It was impossible to compare the cost of shipping livestock by truck and rail, because of the small amount of data available. It can be said, however, that distance does not affect truck rates to the same extent as competition within an immediate vicinity or road conditions.

Cost of Farm Implements. The study includes the farm implement account on 65 farms in Todd County, and 35 in Bourbon County. The figures from the analysis of the Bourbon County data showed a machinery investment averaging \$728 per farm. The total annual machinery charged amounted to 15.6 percent of the original cost of the machinery. Depreciation averaged 7.04 percent of the original cost and annual repairs 4.6 percent. The investment per crop acre for all farms averaged \$7.64 and the total annual cost per crop acre \$3.11. Crops averaged 95 acres per farm. Machinery investment per acre and cost per acre varied with the size of the farm, being

smallest for the large farms. For farms having less than 51 crop acres, the investment per crop acre was \$9.77; for farms having 51 to 100 crop acres, \$8.63; for farms having 101 to 150 crop acres, \$7.93, and for those having over 150 crop acres, \$6.51. The annual cost per crop acre for the farms having more than 150 crop acres was \$2.32, in contrast with \$3.59 for farms having less than 51 crop acres.

Marketing Tobacco. A study revealed that altho both production and consumption of white burley tobacco have increased somewhat during the past twenty years, maladjustments between them have occurred frequently. Yearly fluctuations in production depend upon changes in the acreage grown and in the yield per acre. An analysis of these factors showed that acreage changes have been responsible for about three-fourths of the fluctuations in production, and changes in yield per acre have accounted for the other one-fourth. Voluntary attempts to adjust production to market requirements are more likely to succeed when acreage changes are relatively the more important factor.

Holdings in storage and consumption of tobacco have been compared. Normally, some tobacco is carried over from year to year but the amount of carry-over varies considerably between types. Stocks of white burley tobacco on hand October 1, during the past fifteen years, have averaged about 22 percent greater than annual consumption. Domestic stocks of Green River have averaged 6 percent greater than disappearance, whereas those of One Sucker and the Clarksville and Hopkinsville dark-fired types have averaged about 10 percent less than annual disappearance. Domestic stocks of Henderson Stemming tobacco have averaged only about 40 percent of annual disappearance, based on the last seven years for which data are available. These differences probably are due to variations in manufacturing procedure and differences in export practices. Normal carry-over must be considered in evaluating existing supplies as a price-making factor.

Trends in the acreage, yield per acre and production of all types of dark tobacco grown in Kentucky have been

calculated for recent years. The acreage and the production of Clarksville and Hopkinsville dark-fired tobacco have declined about 1 percent per year since 1918, while those of the Paducah dark-fired type have declined about 7 percent per year during the same period. Yields per acre of both types increased very slightly. The acreage of One Sucker tobacco has decreased about 6½ percent per year and production decreased 7 percent, the yield per acre of this type having declined slightly. Also, the disappearance or consumption of these types has been declining. Similar data for Green River and Henderson Stemming tobacco have been available only since 1923, but they indicate that the same tendencies are present in these types.

A study was made of the prices paid for dark tobacco. When adjustment is made for changes in the general price level, the price of most of these types has tended to rise slightly or show little trend either up or down. That production has declined in spite of steady or slightly rising prices for some types suggests the need for further study of the factors which control production.

Exports by types to different countries are being tabulated in order to study the movement of Kentucky tobacco into foreign markets. The export market may be increasing or decreasing in importance for the various types and shifts in foreign demand may be important price-making factors. Unfortunately, export data by types are not available prior to 1923 and are not so complete as might be desired since that date, but an attempt is being made to compile in usable form all export data available.

Virus Diseases of Tobacco and other Plants. Five mosaic plants were found in approximately 66,600 tobacco plants set on the Experiment Station farm. Counts of mosaic plants were made about three weeks after setting. By harvest time, about 1 percent of the plants had become affected from an undetermined source. This is the sixth consecutive year that the disease has been nearly prevented during the early part of the

season by not allowing men to use barn-cured tobacco while pulling and setting plants.

Studies have been continued on seed transmission of the ringspot virus of tobacco. As the result of finding a previously undescribed ringspot, which has been named yellow ringspot, it was possible to demonstrate seed transmission of the virus within a few days after germination of the tobacco seed. This is because the yellow ringspot virus causes infected seedlings to turn yellow with a few days exposure to light. As high as 15 percent of the seedlings have been found to be affected. Seed transmission of the usual green ringspot has been demonstrated by exposing the seedlings to relatively low temperatures (about 50 degrees F.). Under these conditions, chlorosis and necrosis of the tissues along the edges of the distal portion of partly grown leaves of affected plants take place. Ovule sterility occurs on ringspot plants. In some instances, no seeds are produced and in others nearly a full quota. Usually fewer than half of the ovules develop seed. Ringspot causes partial pollen sterility and the impotent pollen seems to be the direct cause of ovule sterility.

Speck-spot of tobacco, a small, circular, light-brown spot, was traced to infection by any one of several viruses. Typical tobacco mosaics, the etch viruses, veinbanding and cucumber mosaic viruses each caused it in burley tobacco.

A virus disease of plums is being studied which appears to cause gradual loss of vigor and eventually death of the tree. It has now been transferred to seedling peaches from five varieties of plums, Abundance, Red June, October Purple, Bovay, and Shiro. Distinct leaf patterns of the ringspot type were found on the leaves of orchard trees of Abundance, Red June and October Purple. The disease was found in the Abundance variety in a nursery. In the same nursery, a few very typical patterns of the ringspot type were found in the leaves of Elberta peaches.

Angular Leaf-Spot and Wildfire of Tobacco. Previous experience indicated that the usually recommended sanitary precautions, such as clean canvas, treated seed, etc., are not effective

in controlling angular leaf-spot and wildfire in the plant bed. Evidence collected the past year suggested that the bacteria might be washed into the bed during heavy rains. This year, the general planting bed was well trenched to prevent flooding. For the first time in the past eleven years, an unboarded bed on the Station farm was free from the bacterial leaf diseases at pulling time.

Black-Root-Resistant Strains of Tobacco. A root-rot-resistant strain of burley tobacco (No. 5) developed by hybridization was tested more extensively this year. The reports so far indicate that it is very satisfactory. The quality appears to be excellent and it is extremely uniform in type. This, together with its resistance to black-root-rot, makes for uniform growth and ease in stripping and grading. A strain of air-cured dark tobacco developed by hybridization was tested by a few farmers in Daviess County this year. The type of plant is so nearly identical with that already being grown that the two could not be distinguished when growing in soil not infested with the black-root organism. Progress is being made in the development of resistant dark-fired varieties, but they are not yet ready to be given general field tests.

Frenching of Tobacco. Soil was procured from a number of the areas where frenching was present and used in greenhouse work. Turkish tobacco was grown in small portions of these soils, untreated and with additions carrying nitrogen, phosphorus and potassium, singly and in various combinations. The results were in agreement with the previous work in that frenching apparently was associated with nutrient deficiencies of nitrogen, phosphorus or potassium. Perhaps frenching may be associated with a deficient supply of any nutrient entering into protein metabolism. Much of the frenching studied in the field was in tobacco growing on the highly phosphatic soils of the central Bluegrass Region. On these soils, frenching seemingly was associated usually with potassium deficiencies. However, Turkish tobacco grown in the greenhouse in limited volumes of soils from some of these areas frenched when nitrogen was the deficient nutrient. The work also agrees with previous work

it indicating that the underlying soil condition predisposing to frenching is a particular soil reaction or, perhaps more correctly, a particular supply of soil calcium available for plant uptake. The problem is complicated by the fact that frenching has not been found in soils containing large amounts of basic calcium materials. Most of the frenching studied so far has occurred in soils ranging from a little under pH 6.0 to pH 7.5. It should also be noted that soils on which tobacco frenches with a certain nutrient relationship may not at another time produce frenched plants under what would seem to be very similar nutrient relationships. Further, it has been very difficult to produce frenching in sand culture with nutrient and reaction or calcium relationships very similar to what these were believed to be in the soils where frenching occurred.

Effect of Differences in Chlorine Content of Fertilizers on Chlorine Content and Quality of Burley Tobacco. Smoking tests of tobacco grown in 1927 and 1928 showed that potassium chloride applied at the rate of 50 and 100 pounds per acre did not injure the smoking qualities of the tobacco. The application at the rate of 200, 400, and 800 pounds per acre injured the smoking qualities so that the rate of burn and the length of time that the tobacco would stay lighted were decreased and a dark carbon ash was produced. Injury increased with amount of fertilizer application. Applications of potassium sulfate at the rate of 400 and 800 pounds per acre also injured the smoking qualities of tobacco to some extent. In only one of the six years of the experiment did applications of potassium chloride at the rate of 50 pounds per acre noticeably change the appearance or handling qualities of the tobacco. In a number of years, potassium chloride applied at the rate of 100 pounds per acre did not noticeably change the appearance and handling qualities of the tobacco. From the work done, it seems unlikely that applications of 50 pounds per acre of chlorine in fertilizers would injure the quality of burley tobacco on soils similar to those on which the tobacco in the experiment was grown.

Method of Applying Fertilizer to Tobacco. Row application of fertilizer is considered more effective for tobacco than

broadcast application, particularly for White Burley. Certain methods of row application may result in killing the plants or greatly retarding recovery after transplanting. To determine safe and unsafe treatments, a series of tests was begun in 1930 in which the fertilizers are applied in several different ways in the row. All methods gave equally good results in that year, probably because moisture conditions were favorable at time of transplanting. In 1931, the weather was very dry at transplanting time and fertilizers applied in the furrow without any mixing with the soil killed most of the plants, both in hand and machine setting. The extent to which injury occurs depends quite largely upon seasonal conditions. The method of distribution which resulted in killing so many plants in 1931 is practically the same as that provided by the fertilizer distributor on most tobacco transplanters, hence farmers who use the fertilizer attachment on transplanters are in danger of serious losses in some years. It is evident that the experiments must be continued for several years before it will be possible to determine methods that are safe under all seasonal conditions.

Phosphorus Availability. The results of a pot culture experiment in the greenhouse indicate that the smaller yields at the Campbellsville soil experiment field on the lime-phosphate plots as compared with the phosphate alone plots are due, at least mainly, to the effect of the lime treatment in depressing availability of the rock phosphate and not in other ways. A greenhouse pot experiment was carried out, in cooperation with the United States Department of Agriculture, to determine the availability of phosphorus in various phosphorus carriers. The primary purpose of the work was to determine the effect of ammoniating ordinary superphosphates on phosphorus availability. Three ammoniated superphosphates were used representing different degrees of ammoniation and some other common phosphorus carriers for comparison. Turkish tobacco was grown in small volumes of soil from a check plot from the Campbellsville soil experiment field, fertilized with uniform additions of phosphorus in the various phosphorus materials and with uniform supplementary nitrogen and potash additions.

Ammoniation had no adverse effect on the availability of phosphorus.

Iodine in Kentucky Soils, Limestones, Waters and Forage Crops. Comparable results on the same samples of soils have been obtained by the method of combustion in an electrically heated quartz tube and by methods published by previous investigators. The combustion method is less laborious and time consuming than the other methods tried.

Determination of iodine on a rather large number of bluegrass soils shows that they are moderately well supplied with this element. Soils from the eastern part of Kentucky contain about one-half as much iodine as was found in the bluegrass soils. In a few samples of very poor soils, no iodine was found. This indicates that the iodine content in soils may vary widely and may be a more important factor in soil fertility and the growth of plants than has hitherto been supposed.

Analyses of two different crops of watercress show that this plant is unusually rich both in iodine and manganese. It has been recognized for a long time that watercress possesses unusual nutritional properties and vitamin potency. Undoubtedly it possesses economic possibilities in animal nutrition which have not been fully appreciated and utilized to the present time.

Effect of Manganese-deficient Lettuce on the Growth of Rats. Lettuce seeds were germinated at different intervals in manganese-free sand cultures and the seedlings transferred to nutrient solutions with and without manganese, and grown for about six weeks. The leaves of the two lots of plants were fed in equal amounts as a supplement to a synthetic diet, to two groups of young rats, having an average weight of 36 grams. The lettuce plants from which manganese was withheld made a stunted growth and the leaves became pale green whereas the leaves of the plants grown in the solution containing manganese were normal in size and color. Analyses of the two lots gave the following results:

	%
Lettuce leaves grown in the absence of manganese.....	.0006 Mn
Lettuce leaves grown with manganese	.1925 Mn

The experiment was carried on over a period of eight weeks and during this time the rats fed manganese-deficient lettuce made an average gain of only 26 grams, whereas those which received lettuce containing a normal amount of manganese made an average gain of 41 grams. At the conclusion of the experiment, hemoglobin determinations were made on each of the two lots of rats. Those fed the manganese-deficient lettuce had an average hemoglobin reading of 59 percent, whereas the rats fed lettuce containing manganese had an average reading of 76 percent. The results indicate that lettuce grown in cultures containing manganese possess growth-promoting properties which are present to a much less degree in lettuce grown in similar cultures without manganese. This indicates that the nutritional properties of important foods may be affected when the supply of manganese is deficient in the soil in which food plants are grown. The method of experimentation introduces a new procedure for ascertaining which of the less common elements have important functions in the growth of plants and the production of foods of good quality.

Experiments with Yeast. The results thus far obtained show that the rate of growth and size of yeast cells are affected by the absence of manganese, copper and zinc. The rate of growth is much more rapid and the size of the cells somewhat larger in the cultures containing an optimum amount of the three elements.

Boron as a Factor in the Growth of Lettuce. Experiments in purified sand cultures show that boron performs a very important function in the growth of lettuce. At the beginning of the fourth week, the plants from which boron was withheld had developed a few dark spots near the tips and margins of the younger leaves. These spots increased in size and number and, after a few days, the growing points died and turned black, giving the plants a burned appearance. The condition resembled the disease known as "tip burn" of lettuce. All plants from which boron was withheld were affected in this way. Three varieties of lettuce were used and all were affected in a similar manner when boron was withheld from the cultures.

Value of Crop Rotations in Growing Corn. The following results show the importance of rotation in the growing of corn (summary 1920-29) :

	Continuous Corn Bushels	Rotation Corn Wheat Clover Bushels
Average yield unmanured land, 1st year.....	70.0	57.0
Average unmanured land, first 3 years.....	46.6	42.6
Average unmanured land, 10 years.....	34.0	51.3
Average 10 years, 4 tons manure	Manure on each corn crop	60.2
Average 10 years, 6 tons manure		59.1
Average 10 years, 8 tons manure		60.0
Average 10 years, 10 tons manure		62.8
Average 10 years, 10 tons manure	48.8	Manure on alternate crops
Average 10 years, 15 tons manure	47.2	

It is also interesting to note that 4 tons of manure on corn in this rotation are about as effective as larger amounts.

In a rotation of corn and soybeans, with the cornstalks and soybean straw returned and a cover crop of rye each winter, the yield of corn from 7 alternate years, 1915-27 (plans changed in 1928) was 53.1 bushels without fertilizers, and 55.3 with complete fertilizer. For the same years, in continuous culture, with crops removed and no cover crop, the yield was 37.5 bushels without fertilizers and 49.6 with complete fertilizer.

Bluegrass. Bluegrass improvement studies show a remarkable difference between plants in sod-forming qualities as well as in herbage and seed production. The best sod-forming strains promise to prove valuable in the production of clean pastures because of their dense sods. Highest pasture and seed yield apparently are usually not produced by the same strain, tho a few are superior in both. Residual effect of legumes sown with Kentucky bluegrass in 1927 approximately doubled the pasturage from the bluegrass this year. The legumes disappeared from the mixture in 1929.

Improvement of Corn by Crossing. Open-pollinated varieties were crossed with several inbred strains and single crosses

of inbred strains. The results were almost if not quite as satisfactory as when only the selfed strains entered into the cross. For example, a cross of Boone County White with a first-generation hybrid of two good inbred strains gave an average yield of 64.3 bushels an acre as compared with an average yield of 54.7 bushels from adjoining Boone County White check plots. In addition, the corn was sounder and the plants much more uniform and of a more convenient size. Another similar hybrid with Boone County White gave a yield of 63.7 bushels an acre and still another a yield of 63.1 bushels. Even more outstanding than the yield, however, was the great superiority in the quality of the grain. It seems possible that one of the most practical ways of using these inbred strains would be to cross the best with the ordinary open-pollinated varieties.

In the mass selection with Boone County White, which has been carried on for a number of years, the strain developed was compared with a local strain of Boone County White, obtained from one of the seed companies and a pedigreed strain from Richmond, Virginia. The respective yields were 60, 50 and 55 bushels. The careful selection was very apparent in the greater uniformity of the Station strain and particularly in the type of ear produced.

Rate of Seeding Corn. In determining the proper rate of seeding corn, a good many factors must be taken into consideration. For example, in comparing the yielding capacity of corn planted at the rate of 2 plants per hill and 3 plants per hill, experiments have shown that the yield depends largely upon the size of the plant. From a large-growing variety, such as Boone County White, the largest yield is very likely to be obtained with 2 stalks per hill, whereas with the smaller varieties allowing 3 stalks per hill, or its equivalent in drilled corn, often gives the best results. This year, for example, the yield among several early varieties tested was strictly in favor of the 3-stalk hill as compared with the 2-stalk hill.

Fertilizer Placement for Corn. In hill fertilization of corn, the fertilizer was more effective at depth of the seed level or below seed level than above seed level, the fertilizer being placed

CROP YIELDS ON OUTLYING SOIL EXPERIMENT FIELDS, 1931; TREATMENT WITH MANURE ALONE, AND WITH MANURE, LIMESTONE AND SUPERPHOSPHATE

Field Treatment	Corn Bus.		Soybean Hay Lbs.		Wheat Bus.		Grass and Legume Hay—Lbs.	
	M*	MLP	M	MLP	M	MLP	M	MLP
Berea	34.1	49.3	3372	3840	-----	-----	000	3750
Fariston	-----	-----	820	3120	0.9	23.9	260	3380
Campbellsville	28.6	55.8	-----	-----	19.4	37.6	1103	3279
Greenville	39.9	50.3	2990	4250	10.5	33.5	720	4070
Mayfield	47.4	56.0	3125	3750	24.0	37.2	3450	6395
Average	37.5	52.9	2577	3740	13.7	33.1	1109'	4175

* Manure on corn only, and equal to weight of crops removed in the rotation of the previous year.

in parallel bands on both sides of the seed and not in contact with it. One hundred and twenty-five pounds of fertilizer applied in the hill were more effective than 500 pounds broadcast. The trial was conducted on land that had not before been fertilized.

Soil Experiment Fields. The growing season of 1931, following the drouth of 1930, was favorable, as shown by outstanding yields on soils that had been kept in good condition by sound rotation and fertilizer practices. The table on page 28 shows the yields obtained on five soil experiment fields that have been in operation from thirteen to nineteen years.

A very interesting observation was made on the effect of mosaic on the yield and quality of dark tobacco at Mayfield this year. Contrary to instructions, the workmen used tobacco that carried mosaic virus. Later, 43 percent of the plants in the field showed mosaic. The infected plants were harvested and stripped separately. The average yield of the infected plants was 1323 pounds per acre, whereas that of the healthy plants was 1571 pounds. The inferior quality of the diseased tobacco was very apparent. The price rating for the diseased tobacco was 7 cents per pound against 10 cents for the disease-free tobacco.

The harmful effects on the yield and quality of tobacco from over-liming were demonstrated at the Campbellsville field. Two sets of plots, similarly fertilized, were used, one set of which received ground limestone at the rate of 4 tons per acre, in two applications, between 1919 and 1924. The land was a legume and bluegrass sod, manured at the rate of 6 tons per acre. The yield of tobacco per acre and its price per 100 pounds were as follows:

	Without Limestone		With Limestone	
	Yield lbs.	Value per 100 lbs.	Yield lbs.	Value per 100 lbs.
Manured checks	485	\$2.40	598	\$3.17
Manure + superphosphate	816	9.49	882	5.94
Manure + superphosphate + potash..	894	9.32	916	5.93
Manure + superphosphate + nitrogen	990	8.96	1064	5.86
Manure + superphosphate + potash + nitrogen	1034	11.14	1186	6.02

Mixed seeds of various legumes and grasses for the hay crops on the various experiment fields are now used instead of clover alone. The value of a seeding mixture is shown by the following results:

At Campbellsville in 1925, 5 pounds of common lespedeza were included in a mixture of red clover, alsike clover and timothy. The clover and timothy were a practical failure, but the lespedeza reseeded itself and produced a good stand which was harvested in 1926. The yield averaged 1360 pounds per acre for untreated soil, and 2440 pounds per acre for the plots treated variously with limestone and fertilizers. Some of the treated plots yielded more than two tons per acre.

The value of a mixture is also shown in good seasons with all the plants in the mixture making a stand. The seedings of 1928 and 1929 at Campbellsville consisted of red clover, alsike clover, common and Korean lespedeza, timothy and alfalfa. The seeding of 1929 made sufficient growth for a cutting that year, while the 1928 seeding was cut twice in 1929. Typical yields for the three cuttings are 3780 pounds for a check plot without limestone or fertilizer, 10,590 pounds for limestone and superphosphate, and 11,410 pounds for limestone, superphosphate and potash. The average yields for clover alone for three crops preceding the use of the mixture were 860, 2303 and 2150 pounds, respectively, for these treatments, with no first-year cuttings or aftermath cuttings worth while. The hay was grown in rotation with corn and wheat.

The effect of reserves of phosphorus accumulated in the soil from regular application of phosphate since 1913 is being studied at the Berea experiment field. Up to 1930, 2600 pounds of superphosphate and 5200 pounds of rock phosphate per acre had been applied to the respective plots. In 1930, the plots on which corn was grown were divided, one-half receiving the usual application of phosphate, and the other half, none. The corn crop was practically a failure on account of the drouth, so that the results were not significant, but soybeans were grown in 1931 on these plots without the addition of fertilizers to either half. The average yield on the half plots that received superphosphate the preceding year was 4200 pounds and on the half plots that did not receive it, 4320 pounds. The half plots that received rock phosphate averaged 4184 pounds and those that did not, 3872 pounds. In 1931, the same procedure was followed on another series of plots for corn. The average yields with and without superphosphate were 52.9 and 57.5 bushels, respectively. Comparative yields for the rock phosphate plots were 55.5 and 56.9 bushels. These studies will be continued on this and other experiment fields.

Cooperative Strawberry Marketing. Data were obtained from seven cooperative associations for the 1931 marketing season. These include volume of business, costs of operation, destination of fruit, prices received, pooling practice and other information of problems of management of strawberry marketing associations. This is the third year in which comparable data have been obtained for the associations in Kentucky. The analysis of the business of these organizations for 1929 has been completed and published in Kentucky Agricultural Experiment Station Bulletin 319, entitled Organization and management problems of cooperative strawberry marketing associations in Kentucky.

Strawberries. The new Blakemore strawberry which fruited this year for the first time gave disappointing results compared with the Premier. The stand and appearance of the Blakemore plants appeared better than the Premier, but the yield was less and the size of the berries averaged rather small. The very dry

weather at harvest time provided a rather rigid test of the adaptability of these two varieties to withstand drouth. A test of the effect of removing blossoms when plants are set was begun last spring with the Premier variety. Ninety-eight percent of the plants grew when the blossoms were removed in contrast to 83 percent of those with blossoms left intact. The plants which grew with blossoms intact produced less than half as many runner plants as those which had their blossoms removed.

Summer and Winter Cover Crops for Peach Orchards.

This project was undertaken with the object of overcoming the troubles commonly attributed to *Bacterium pruni*. Where a good stand of sweet clover has been maintained in peach orchards for two years, the trees were found to have improved remarkably in color and growth and matured fruit of good size. Manured sweet clover has given as high yields and nearly as large fruit as a manured plot in which a winter cover crop of rye was grown and disked under. Rye, used as a winter cover crop and disked in when in the early stage of bloom, a stage usually thought too late, introduced a large amount of organic matter quickly into the soil. Following disking, no check to the growth of the trees was noted in the two years this system has been used, and the fruit was very satisfactory both years.

Thinning Peaches. Forty-five trees in the 6-year old Elberta orchard were used in a trial to determine the period over which effective thinning can be done. The thinning was done over a period of about six weeks following the "June drop," namely on June 2, June 15, July 1 and July 15. The fruit was thinned as nearly as possible to six inches apart. The thinning on June 2 was done just before the pits began to harden. This is the customary practice of growers since it is believed that thinning after the pits harden is not so effective in improving the size of fruit. Twice as many fruits were removed in thinning on June 2 as on the later dates, thus requiring almost double the labor cost. The number of fruits harvested per tree was remarkably uniform from the thinnings of June 2, June 15 and July 1, respectively, while the number of

fruits per tree was somewhat less for the last thinning on July 15. There were no significant differences in the size of fruit from thinning on the different dates. The data indicate that thinning may be done effectively over a much longer period than has been practiced generally. Labor may be saved by delaying the operation until all the seasonal "drop" has occurred and the longer period for thinning should be more economical of labor than the usual practice of employing extra help to complete the thinning before the pits harden.

THINNING RESULTS

(1931)

Date thinned.	No. trees	No. fruits removed	No. fruits harvested	Av. No. fruits harvested per tree	Av. wt. fruit harvested (lbs.)	Av. size each fruit (ounces)
June 2, pits soft	12	15,939	14,928	1324	232.0	2.89
June 15, pits hardening	10	6,698	14,549	1454	233.2	2.53
July 1, pits hard	12	6,322	16,781	1398	248.8	2.90
July 15,	11	4,993	11,671	1061	160.8	2.68

Growth and Fruit Size. The shoot growth of 22 trees was measured for comparison with the size of fruit produced. No direct correlation was found between length of shoot growth and fruit size, but by placing all the trees with shoot growth between 15 and 20 inches long in one group, those between 10 and 15 inches in another, and those less than 10 inches in another, it was found that the trees making the greatest shoot

growth produced larger fruit, on the average, than those which made less growth. While the results are not conclusive, the data indicate that tree vigor may have an important influence on fruit size.

Codling Moth and Spray Study. In the spring of 1931, a project was undertaken cooperatively with the State Horticultural Society for the study of the codling moth and the development of a spray service program for orchardists. It was expected that the spray service would be preliminary to a larger program to be developed for assisting the orchardists throughout the state. The Experiment Station furnished the professional services and the State Horticultural Society provided the funds necessary for travel and certain office expense.

Three insectaries were established, one each at Henderson, Paducah and Louisville. Observations and studies were made in these localities on the activity of orchard insects in general, but more particularly to determine the time of emergence of the codling moth, the period of egg-laying, incubation periods, worm activity and the activity of the moth. Temperature and rainfall data were collected to aid in determining the time of emergence and the period of incubation. From these studies, it is possible to follow closely the activity of the insects and to forecast with a higher degree of accuracy the proper time to apply sprays for their control. The information gathered was disseminated to the fruit grower through the offices of the county agents. The service proved highly satisfactory. Orchardists made many comments as to the value of the service, and its resulting economy of labor and spray materials.

Leafhopper Study. The clovers used in the study were grown from seed from Kentucky, Tennessee, Wisconsin and Oregon. The Kentucky and Tennessee clovers were the least affected by leafhopper injuries. The Kentucky strain was not injured so severely as the Tennessee strain. In previous experiments, it was found that the Italian and French red clovers were less resistant to leafhopper injuries than native strains.

Tests for Increasing Yield of Vegetables. Fourteen plots of tomatoes were used to test the value of sodium carbonate

with lime and manure, or combinations of them, on yield. In all trials lime and sodium carbonate or sodium carbonate alone resulted in increased yields over checks. Lime alone tended to decrease the yield. Manure with these materials did not always increase the yield except where the alkali applications were heavy. The largest yield occurred on the plot that received two tons of hydrated lime and two tons of sodium carbonate per acre; with manure. The early yield was increased by sodium carbonate, whereas lime decreased it. No consistent increases were obtained by the application of manure alone.

A large increase in the yield of cabbage was obtained from the use of lime and sodium carbonate. Three tons of limestone and one-half ton of sodium carbonate per acre gave about the same results as one ton of hydrated lime and one ton of sodium carbonate per acre. The addition of manure had little effect on yield.

Sodium carbonate, alone or with lime, gave increased yields with cucumbers, except where sodium carbonate was applied at the rate of two tons per acre, which application was probably too heavy. The addition of manure increased the yield over checks, in most trials.

Heavy applications of lime or sodium carbonate or a combination of them resulted in poor germination and a scattered stand of lima beans and of snap beans. Moderate applications increased the yield of each. Manure alone produced no practical effect on yield either of lima beans or of snap beans.

Time for Planting Late-Crop Potatoes. Potatoes were planted at two-week intervals from July 15 to August 15. Those planted July 15 produced the best yields. The yields were progressively lower for each successive planting.

Tomatoes. A study is being made as to the relation of nitrate, phosphate and soluble carbohydrate ratios in the petioles of tomatoes to growth and yield. The work to date indicates that there is a definite relationship between the nitrate and phosphate content of the tomato plant and the growth and yield. The nitrate-phosphate ratio for the five high-yielding plots in the fall 1930-31 crop averaged 1.8 and

the spring crop 1.74. This points definitely to a favorable ratio lying somewhere between 1.5 and 2.0. The results indicate that if the level of nitrate and phosphate content in plants is raised and the ratio of 1.8 maintained, the yield is increased. However, if the nitrate content is high and the phosphate content relatively lower, giving a higher ratio, the yield has been low despite the fact that large, healthy vines are produced. On the other hand, if the nitrate content is relatively low and the phosphate high, giving a low ratio, the vines are smaller, the leaves yellowish and the yield low.

The results obtained on the relation of soluble carbohydrate content of the plant to growth and yield have not been consistent. Attention has been turned to the potassium content of the plant as the main controllable soil factor which governs carbohydrate synthesis and metabolism. The data on this relationship are incomplete at this time.

The work to date indicates that the nitrate, phosphate and potassium content of the plant may be regulated by fertilizer practice, and that the determination of the ratios which result in high yields would provide a basis for fertilizer recommendation which may have far-reaching value in the growing of truck crops and perhaps other crops as well.

Sorghum Sirup Studies. A variety of saccharine sorghum obtained from Morgan County, Kentucky, was substituted for corn on the Fariston soil experiment field and sirup made from the crop. The limestone, acid phosphate and potash treated plot on manured soil produced the highest yield of sirup (209 gallons of 12 pounds each) which was approximately four times the yield from the manured but unfertilized plot. Plots that received barnyard manure in addition to limestone and fertilizers produced a lower quality of sirup, on the whole, than similarly treated plots without manure. A variety test was made with three local mountain varieties and Amber and Orange of commercial origin. The local varieties produced from five to seven times more sirup to the acre than the Amber and Orange varieties, and the quality of the sirup was somewhat superior. The local varieties were much more uniform in stalk characters and maturity than the commercial varieties.

Longevity of Agar Slab Cultures of Some Pathogenic Germs. Agar slab cultures of *B. coli*, *B. paracoli*, *B. anthracis* and *B. paratyphosus* B., which were made and carefully sealed with sealing-wax on September 2, 1913, were kept in the refrigerator without breaking the seal, until October 3, 1930, when transfers were made and luxuriant growths obtained. Cultures of *B. mallei* and *B. bronchicepticus* were treated in the same manner, but no growth was obtained from them. After the cultures were made, the tubes were again sealed and kept in the refrigerator until November 20, 1931, when they were transplanted on agar slants. *B. coli*, *B. anthracis* and *B. paratyphosus* B. produced abundant growths, but *B. paracoli* had died during the year. It is interesting to note that *B. coli* and *B. paratyphosus* B., which are not spore-bearers, remained viable for over eighteen years, as well as *B. anthracis*, which is a spore-bearer, while *B. paracoli* lived for more than seventeen years in sealed agar tubes.

Streptococci. In the study of streptococci isolated from genital infections and prenatal diseases of the horse, the organisms were found to possess the characters generally attributed to human streptococci. The cultures were strongly hemolytic in fluid mediums, did not hydrolyze sodium hippurate, produced only a low acidity in glucose and failed to reduce methylene blue. However, it was found possible to differentiate 95 percent of these cultures from streptococci of human origin by their fermentative reactions. A series of 35 human strains were all able to ferment trehalose but failed to ferment sorbitol. In a series of 90 equine cultures, 86 were able to attack sorbitol, but failed to ferment trehalose. The remaining four cultures resembled the human strains in their action on fermentable substances.

In studying streptococci from cows, hogs, chickens and foxes, they were found to resemble the group of equine strains described above, 95 percent of them fermenting sorbitol but failing to attack trehalose. *Streptococcus equi* can be distinguished from the human streptococci and the other animal

strains by the fact that it ferments neither trehalose nor sorbitol. These fermentative reactions give promise of being of great value in the differentiation of human and animal hemolytic streptococci.

Corynebacterium Equi. This organism has been isolated from four foals affected with purulent pneumonia. It has been found associated with pneumonia in which abscess formation is the most prominent post-mortem finding. So far as is known, this is the first time that this infection has been found in the United States or reported outside Continental Europe.

Infectious Abortion. Extended agglutination tests for infectious abortion were made from the blood of aborting cows where the usual test by using only bovine strains for the preparation of the antigen employed did not designate all the known aborting cows. The blood of two aborting cows responded negatively to 25 individual antigens made from different individual strains of *Br. abortus* (Bang), also negatively to antigens made from strains of *Br. melitensis*, but were positive to the antigens made from strains of *Br. suis*, indicating that the cows were infected with a swine strain of the organism. In the test of another herd of cows, where infectious abortion existed, the blood of 22 cows responded positively to the agglutination test in all 25 antigens made from individual strains of *Br. abortus* (Bang); two of these were also positive to *Br. melitensis*.

Work was started to differentiate strains of *Brucella abortus* (Bang) *Br. abortus suis* and *Br. melitensis* and a strain of *Brucella* obtained from a human by the agglutination absorption test. The work has not progressed sufficiently to make a complete report. However, the strain isolated from a human was classified as a bovine type by this test. Also, one bovine strain isolated from an aborting heifer several years ago was classified as a swine strain by the agglutinin absorption test and all other tests except its growth requirements. This culture required several successive subcultures in a reduced oxygen tension, before it adapted itself to aerobic growth. In this respect, it was like the bovine strains of *abortus*. Bacterin

was prepared for 450 head of cattle in twenty herds. Five bovine fetuses were cultured. *Brucella abortus* (Bang) was isolated from one, a streptococcus from one, and the others were negative.

Three swine samples of blood were tested for infectious abortion. Bacterin was prepared for 10 head. A pig with swollen joints filled with pus, thought to be caused by *Br. suis*, was cultured. The infection was found to be due to a streptococcus.

A vaccine prepared from *B. abortivo-equinus* was administered to 2365 mares on 51 farms. Forty-three equine fetuses were cultured. The *B. abortivo-equinus* was isolated from five of these fetuses and a streptococcus from three. Forty-five equine blood samples were tested for infectious abortion. In three of the 69 herds of mares vaccinated in the late summer and fall of 1930, two mares aborted in the early months of 1931. This was found to be caused by a virulent strain of the *Bacillus abortivo-equinus*. The mares in these three herds were re-vaccinated with an autogenous vaccine. In one of the herds, there were two abortions after re-vaccination with the autogenous vaccine; in another herd of a hundred mares, one mare aborted and in the third no abortions occurred after the autogenous vaccine had been used.

Bromthymol Blue Test for Mastitis. This test has been applied to 492 samples of milk. Each sample represents one quarter of the udder. A Bang abortion infected herd, numbering 14, furnished 272 of these milk samples. Of this number 177 were negative to the bromthymol blue test, 23 were doubtful, and 72 were positive. The 72 positive tests were obtained on the milk of 9 of the 14 animals in this group. Six of the cows showed clinical evidence of mastitis. Three had past histories of mastitis. The health record of this group was not so complete as the records for the Bang abortion disease-free group. The Bang abortion-free group, numbering twenty, furnished 220 of the milk samples. Four of these samples gave a doubtful reaction to the bromthymol blue test, 215 were negative and one was positive. The sample that was positive to Bromthymol

blue test for mastitis came from an animal that had calved recently; subsequent tests were negative. The doubtful tests represent two animals. The udder of one of these cows had been injured, while the other animal was off feed. Tests applied to milk from these animals at a later date were negative.

This test if properly interpreted is of great clinical value for the detection of mastitis. The clinical condition of the animal and the stage of lactation should be taken into consideration. Cows that have calved recently, those approaching the termination of lactation and sick animals often give a suspicious or positive reaction altho the udder is not diseased.

Glandular Therapy. During the past three years, seven cows and nine heifers have been given intravenous injections of glandular extract in the treatment of delayed conception or temporary sterility. The clinical conditions for which the cows were treated were failure to come in oestrus, temporary sterility and endometritis. All the cases treated terminated satisfactorily except the one treated for endometritis.

The nine heifers were treated for failure to come in oestrus and delayed conception or temporary sterility. Eight of the nine cases treated for temporary sterility conceived promptly. However, five of the heifers aborted at an average gestation period of 151 days. Two cases treated for failure to come in oestrus terminated satisfactorily, tho one of the heifers never became pregnant. All the animals in the heifer group were negative to Bang abortion disease. Some that aborted were bred later, conceived and produced normal calves. From the standpoint of glandular therapy, it appears that all the cases treated, except two, responded to the treatment. The average service per pregnancy for heifers after treatment was 1.2. The cases that failed to respond to treatment were one endometritis in an aged cow and one permanent sterility in a heifer.

Acidosis of Pregnant Ewes. Continuation of the work on acidosis of pregnant ewes has furnished further evidence that the disease is directly related to an upset of the normal metabolic processes due to a partial or total absence of essential nutritional elements. Examinations of the blood and urine

indicate that in most cases, the blood calcium and potassium are low, and the blood phosphorus high. This condition comes on gradually and the proper balance is reestablished with difficulty. The proper mineral balance is best maintained by using feeds in which mineral substances are present in proper amounts and in a form making them readily available. In general, the blood of normal pregnant ewes shows calcium 10, potassium 20, and phosphorus 5, or a calcium-phosphorus ratio of 2. In most cases of acidosis the calcium content of the blood is low. In some, the calcium may be normal, but the phosphorus shows a noticeable increase so that the calcium phosphorus ratio is abnormal. The calcium phosphorus ratio in eight cases of acidosis examined was .96, 1.37, .68, 1.0, 1.14, .90, .79 and 1.34, respectively.

Salmonella Pullorum. In the study of variants of *Salmonella pullorum*, large-colony forming strains which have a decidedly greater vigor of growth than normal strains have been isolated from stock cultures. While these strains resemble the other members of the genus *Salmonella* in rate and amount of growth, yet they are bio-chemically and serologically identical with normal strains of *S. pullorum*. Since they produce a large amount of growth, their use in the preparation of antigen for the agglutination test may be of value.

The Nutritive Value of Eggs as Affected by the Feeding of Cod Liver Oil to Hens. The importance of the hen's egg in the dietary of man gives imperative interest to the investigation of its nutritive properties. Some constituents that occur in minor amounts in food substances have, nevertheless, been found to be of major importance to the health and well being of man. Some of these minor constituents in eggs have had very little study given to them. Information is especially lacking on the effect variations in feeding and environment of the hen may have on the nutritive factors of the egg. Among these factors minerals and vitamins are as important as any. Since an equilibrium of minerals affects the chemical reaction of eggs and since functions of the living cell are so dependent on the proper reaction, the first step in investigation of the effect on the egg

of variations in the feeding, environment of the hen was a study of the pH of the yolks and whites of fresh and storage eggs.

The eggs upon which determinations were made were produced by hens kept in three pairs of pens, one of each pair of pens being given cod liver oil in addition to the controlled, balanced diet which did not contain cod liver oil. In the first pair, pens 1 and 2, the hens were kept in confinement, and received sunlight only thru glass; the second pair, pens 3 and 4, were confined but had the run of a screened porch so they got all the available sunlight every day; in the third pair, pens 5 and 6, the hens were allowed open range. The hens in pens 2, 4 and 6 were given a quantity of cod liver oil, equal to two percent of their ration.

The results indicate that storage increases the pH of both whites and yolks. The whites of eggs from pen 6 on open range and receiving cod liver oil, show a higher pH than those from pen 5, also on open range, but receiving no cod liver oil. Those from pen 4, confined but receiving direct sunlight and cod liver oil, also show a higher pH than those from pen 3, receiving no cod liver oil. The opposite is noted in the pair of pens confined and not exposed to sunlight. In this case, the pH of the whites of the eggs from pen 2, given cod liver oil, is lower than that of the whites from pen 1, receiving no cod liver oil. While the differences are slight, yet they seem to have a significance in that the results are parallel to those obtained on fresh eggs.

The determinations on the yolks of storage eggs show somewhat different figures, since it was only in the pair of pens on open range that the pH of the eggs from the pens receiving cod liver oil showed higher values than from those not receiving cod liver oil. The reverse was true of the eggs from the other two pairs of pens, namely, that the pH values were lower in the eggs from the pens receiving cod liver oil than in those not receiving it.

Calculation of the correlation coefficient showed, rather surprisingly, that practically no correlation exists between the

pH of the yolks and the whites of the fresh eggs, but that a fair degree appears in the storage eggs from the pens allowed bluegrass range. A less degree, but still a significant one, appears in the eggs from pen 2, confined without sunshine but given cod liver oil.

Total phosphorus of the ash of yolks of fresh eggs shows lower values in those from the pens receiving cod liver oil than in those not receiving oil, except in the case of the hens confined without sunlight, in which the reverse is true. The figures for calcium and for acid-soluble organic and inorganic phosphorus do not vary in the same way. Calcium shows an increase in pens 2 and 6, but a slight decrease in pen 4. Acid-soluble inorganic phosphorus shows a parallel variation, namely, an increase in pens 2 and 6, and a decrease in pen 4. Acid-soluble organic phosphorus shows an increase in pens 4 and 6, and a decrease in pen 2. Correlation coefficients on these figures are in the process of being made.

Technique of Hydrogen Ion Determination. A quinhydrone electrode was used for testing the pH of fresh eggs, but for storage eggs it was necessary to use the hydrogen electrode because of the greater alkalinity of storage eggs. With the type of hydrogen electrode used, it was extremely difficult to make determination without diluting the sample with distilled water. Also, it was more convenient to dilute the sample when using the quinhydrone electrode. Consequently, the question arose as to the effect of dilution. Also, it was necessary to know the effect on pH of the material standing exposed to air, because quantitative weighings for other determinations delayed the determination of the hydrogen concentration from ten to forty-five minutes. From comparisons made on yolks and whites, using both the quinhydrone and the hydrogen electrode, the conclusion was reached that dilution and a moderate amount of standing, i. e. up to 30 or 40 minutes, did not have any appreciable effect on the hydrogen ion concentration. Also, the values found with the quinhydrone electrode were practically the same as those with the hydrogen electrode until a pH of 8.0 or more is reached.

Metabolism in the Chicken. The rate of growth of chicks was determined under three separate sets of conditions, namely: Lot 1, raised in a colony brooder house, with access to a grass run and direct sunlight; lot 2, raised in a battery brooder, with direct sunlight excluded for the first six weeks and then given access to a grass run, direct sunshine and other conditions identical to those of lot 1; and lot 3, raised in battery brooders and fattening batteries until the laying age and then transferred to laying pens; grass run and direct sunlight excluded thruout the experiment. The ration fed these three lots of chicks was the same and had been found experimentally to supply all the necessary food factors for the growing chick. The chicks in lot 1 did not grow quite so rapidly during the first six weeks as those in lots 2 and 3. There were no marked differences in the weights of the three lots of chicks during the twenty-four weeks over which the experiment extended. After ten weeks of age, the chicks of lot 1 appeared more vigorous and developed nearer normality than those in lots 2 and 3.

In comparing the physical development of chicks raised in colony brooders under normal farm conditions with that of chicks raised in battery brooders under experimental conditions, it was noted that the combs of the cockerels raised in battery brooders weighed more than twice as much as those of cockerels raised in colony brooders. The combs of the pullets differed in like manner, but to a less degree. The testes of the cockerels raised in colony brooders were nearly twice as large as those of cockerels confined in battery brooders, and those of the latter group were small and in two instances rudimentary.

The cause of the production of large combs and small testes in cockerels raised in confinement and in the absence of direct sunlight is unknown. It is suggested that the enlarged combs were associated with the exclusion of direct sunlight, the cockerels elaborating larger combs with larger surfaces to compensate for the decreased quantity of solar radiation received. The development of smaller testes may have been due to the decreased quantity of solar radiation received by the cockerels.

Effect of Outcrossing on Egg Production. The plan of

work was described in the 1930 annual report. The three White Leghorn outcrosses were continued, F_2 containing $\frac{1}{4}$ outcross blood and $\frac{3}{4}$ Kentucky blood completing the year, and pullets of the F_3 generation raised and housed. Table summarizes the results to date.

AVERAGE EGG PRODUCTION

Source of Male	F_1		F_1		F_2	
	Foundation Hens		1929-30		1930-31	
	Winter	Year	Winter	Year	Winter	Year
Ky. Strain	70	224°	60	193°	61	179°
Beall I	61	223°	58	195 ¹	59	163 ²
Australian	67	225°	70	203 ¹	76	198 ²
Beall II	67	223°	55	187 ¹	70	213 ²

Winter = Nov., Dec., Jan. and Feb.

⁰ = Ky. Exp. Sta. strain; ¹ = $\frac{1}{2}$ Ky. blood; ² = $\frac{3}{4}$ Ky. blood.

The Beall I bloodline failed to show improvement over the Kentucky linebred check pens, whereas the Beall II and Australian outcrosses proved beneficial in both the F_1 and F_2 generations. Considering both generations, the Kentucky strain has produced 21 hens that laid 200 eggs or more, the Beall I line 20, the Australian line 40, and the Beall II line 52 (highest hen 291). The foundation male of the Beall II line was decidedly superior in pedigree to the Beall I foundation male, altho there was no apparent difference between the males in vigor, conformation and those physical features generally considered as "egg type." The results indicate that the beneficial effects of an outcross can be retained by back-crossing sons of the outcross male to the foundation females and their progeny.

Methods of Feeding Grain to Chickens. A comparison of feeding grain in open hoppers with the commonly practiced method of litter feeding was made with two pens of White Leghorns and two pens of Barred Plymouth Rocks, each containing 100 pullets. The same dry mash mixture was self-fed in all four pens and the grain consisted of equal parts of shelled

corn and wheat. Both the White Leghorns and the Plymouth Rocks in the self-fed pens consumed more grain in proportion to mash than in the litter-fed pens. In the course of the year, the self-fed pens of both breeds consumed twice as much grain as mash. The pens of both breeds fed grain in the litter did not consume so much grain as the other pens, their ration being 1.6 pounds of grain to each 1 pound of mash for the entire year. A table of the results is given.

HOPPER AND LITTER FED GRAIN

Pen	Grain Fed	Avg. Production		Avg. Feed Consumption Pounds
		Winter	Yearly	
White Leghorn				
1	Hopper	75	191	79
2	Litter	74	190	74
Barred Rocks				
3	Hopper	75	181*	89
4	Litter	82	188*	84

* 11 months.

The hatchability and fertility were high in all pens, there being no significant difference between those that were hopper fed or those fed grain in the litter. While the hopper-fed pens consumed slightly more feed than the respective litter-fed pens, yet the cost of feeding was no greater, since they consumed a larger proportion of grain which cost less than the mash. Hopper feeding of grain which keeps the feed in a more sanitary condition, is preferable since the hopper-fed White Leghorns laid equally as well and the hopper-fed Plymouth Rocks nearly as well as the corresponding pens fed grain in the litter.

Cracked Wheat vs. Cracked Corn for Cows. A 90-day feeding trial was conducted to compare cracked wheat with cracked corn in a mixture with ground oats and cottonseed meal as a feed for dairy cows. The data obtained indicate that there is no great difference in the feeding value of cracked wheat and

cracked corn when mixed with bulky ingredients. A slight advantage was noted in favor of the cracked corn.

Corn vs. Wheat for Hogs. A comparison was made of corn with wheat in growing and fattening hogs. Wheat and corn were fed in different forms so as to determine their comparative values in swine feeding. Where the prices of corn and wheat were about equal, wheat proved to be a good substitute for corn. A tendency was noted, however, for the hogs that received wheat to go off feed occasionally.

Shelled Corn vs. Cracked Wheat for Steers. A test was conducted from October 28, 1930, to April 22, 1931, inclusive, a period of 177 days, to compare the daily rate and economy of gains of 10 yearling steers fed shelled corn and 10 yearling steers fed cracked wheat. The average daily ration of the corn-fed steers was shelled corn 11.9 pounds, cottonseed meal 2 pounds, corn silage 25.5 pounds, oat straw 1.47 pound, ground limestone 2.24 ounces and salt .38 ounce. The average daily ration of the steers fed wheat was cracked wheat 11.9 pounds, cottonseed meal 2 pounds, corn silage 25.7 pounds, oat straw 1.33 pound, ground limestone 2.24 ounces and salt .38 ounce. The initial average weight of the steers which were fed corn was 723 pounds per head and of the wheat fed steers 719 pounds. The average gain per steer during the entire feeding period was 363 pounds for the corn fed steers and 416 pounds for those fed wheat. The average daily gain per steer was 2.05 and 2.35 pounds, respectively. The cost per hundredweight gain of the corn-fed steers was \$13.03 and of the wheat-fed steers \$10.87. An examination of the carcasses as well as a chemical analysis of fat from them showed that the carcasses of the corn-fed steers were but slightly firmer than those of the wheat-fed steers. The corn-fed steers dressed 60 percent; the wheat fed, 60.5 percent. Cottonseed meal cost \$34.50 a ton; oat straw, \$14; corn silage, \$5; corn, 80 cents a bushel; wheat, 80 cents.

Feed Control. The feeding stuffs law has been in operation since June 11, 1906. The years immediately preceding and succeeding its passage were marked with evils common at that time to a large percentage of mills in the manufacture and dis-

tribution of commercial feeds. The passage of the law was the beginning of a great change for the better in the manufacture of feeds. The twenty-five year period has witnessed pioneer work in the feed industry. In the administration of the law, a policy of education as well as control is followed and a very high standard of feeds is maintained in the state. Kentucky feeders are well protected and are now offered as high quality feed as can be found on the market of any state in the Union.

Analyses have been made of 1361 samples this year. Of this number, 182 were analyzed for consumers and dealers and 82 for miscellaneous purposes. Eight state cases were filed for prosecution and concluded successfully. Nine federal cases were filed for prosecution.

Fertilizer Control. The registrations for the year covered 739 different brands of fertilizer for which 2,570,000 tags were issued. Farmers and inspectors submitted 823 samples of fertilizer for analysis, the results of which will be published in a bulletin.

Creamery License. Licenses were issued to 12 creameries, 4 cheese factories, 6 condenseries, 44 milk plants and ice cream manufacturers, 37 independent operators of cream stations and 887 cream stations operated by creameries. These licenses authorize their holders to buy milk and cream on the basis of the butterfat content, for the period ending June 30, 1932. Of the number issued, 953 were renewal licenses and 37 for new buying places beginning operation since June 30, 1930.

There are 1,139 authorized testers in Kentucky, 946 of whom hold renewal licenses granted July 1; 102 are new operators licensed since that date and 91 are operating on permits. Twenty-six examinations for tester's license were held at various points and notification was sent to 394 persons. Of the 236 persons who took the examination, 224, or 95 percent, made a passing grade.

The inspections numbered 791 and included 9,053 individual tests, or an average of 11.4 per inspection. Inspections of A, B and C grades (excellent to mediocre ability with apparent endeavor to comply with the rules and regulations) totaled 671.

There were 120 inspections of D grade, causing the operators so inspected to be placed on probation. Seventy-one unstamped and worn weights found in use were taken up and 35 of these confiscated as being under the tolerance allowed. Glassware inspected and stamped totaled 10,677 pieces. Eight pieces were rejected as inaccurate and 18 because not of Kentucky standard.

The Examining Board met three times during the year. Sixteen testers were called before the Board because of unsatisfactory testing. Acting upon the recommendation of the Board, the licenses of nine of these testers were revoked, one permit was recalled, issuance of renewal license was refused to three and three were placed on probation for further consideration after additional inspections have been made of their work.

Regulations under the law for sampling and testing milk bought on the butterfat basis were drawn up, approved and put in force. These regulations provide fair and accurate sampling and testing both for the producer and buyer and permit a more comprehensive check on accuracy of testing, records, etc.

The receipts for the year were \$8,998.50 and the expenditures \$10,022.10 as itemized:

Salaries	\$7,828.33
Labor	294.97
Postage and stationery ..	367.34
Freight and express	4.86
Sundry and laboratory supplies	95.32
Travel	1,419.88
Furniture and fixtures	1.40
Contingent	10.00
Total	\$10,022.10

Public Service Laboratories. The work of these laboratories continues to show a substantial yearly increase in volume. The total number of samples examined in 1931 was 94,795, or about 5,000 more than last year. Of this number, the drug laboratory handled 44 samples submitted by the State Board of Health and 258 samples received from other sources, which included milk, ice cream, breast milk, waters, liquors, human

and animal specimens for toxicological examination. The food laboratory examined 2,083 samples, its work being almost three times that of last year, largely as the result of a state-wide milk campaign, the investigation of food products for "corn sugar" and the examination of apples for excessive spray residue. Physicians from all over the state are presenting special problems to the bacteriological laboratory in ever increasing numbers, many of which require special investigations. The records show that 92,410 bacteriological and serological tests were made during the year and that samples were submitted by 1,391 physicians, county health departments, hospitals, clinics, etc.

Seed Inspection. Analyses have been made of 4,279 samples of seed. The number tested for purity was 2,407, and for germination, 3,727. The distribution of samples is as follows: grasses, 1,173; clovers, 1,269; vegetables, 134; large seed, 552; tobacco, 1,151. Tobacco seed cleaned, 626 pounds.

Nursery Inspection. The most common pests in nurseries were San Jose scale and bag worm. Of less importance were red spider, oyster shell scale, pine leaf scale, woolly aphis and iris borer. Of the diseases, crown gall and willow canker were most prevalent. Inspections were made on 139 premises. Certificates were issued to 59 resident nurseries and permits to 124 non-resident nurseries and 39 agents. Thirty-two dealers have been given licenses.

Personnel. The staff of the Experiment Station is shown on page 3 of this report. The appointments and resignations for the year follow:

Appointments:

Todd Green, assistant bacteriologist department of public service laboratories, July 1.

Fred Boyd, assistant in rural life studies, department of farm economics, September 1.

G. H. Wiggin, forester, Robinson Substation, October 1.

Transfers:

Z. L. Galloway, field agent in farm management, to assistant in farm management, December 1.

W. M. Insko, Jr., assistant in animal nutrition to assistant in poultry husbandry, December 15.

Resignations:

- W. G. Finn, assistant in farm management, July 25.
W. Brooks Hamilton, assistant bacteriologist, August 31.
C. J. Maupin, field agent in poultry improvement, October 5.
J. G. Pelphrey, assistant in the department of chemistry,
September 30.
E. K. Borman, bacteriologist, department of public service
laboratories, December 31.

New Projects:

- Farm real estate taxation in Kentucky.
Agricultural prices.
A study of economic and social conditions of the Kentucky
Appalachian highlands.
A study of rural community organization in selected com-
munities in Kentucky.
Breeding for longevity and long time egg production.
A study of aseptically drawn milk and the udders in which
it was produced.
A study of orchard and nursery pests and diseases with
special reference to the biology and control of the codling moth.

Publications:

Bulletins:

No.

314. The effect of soil reaction on the growth of tomatoes
and lettuce and on the nitrogen, phosphorus and
manganese content of the soil and plant, E. M.
Emmert. March, 1931.
315. Commercial feeds in Kentucky in 1930, J. D. Turner,
H. D. Spears, W. G. Terrell and L. V. Amburgey.
June, 1931.
316. The standard of living of farm families in Grayson
County, Kentucky, Merton Oyler. June, 1931.
317. Farm organization and management in Grayson County,
W. L. Rouse, H. W. Hawthorne and Z. L. Galloway.
July, 1931.
318. Adaptability of red clovers from different regions, to
Kentucky, E. N. Fergus. August, 1931.
319. Organization and management problems of cooperative
strawberry marketing associations in Kentucky, C. D.
Phillips and D. G. Card. August, 1931.

320. Studies on *Shigella equirulis* (*Bacterium viscosum equi*), Philip R. Edwards. September, 1931.
321. Effect of hydrogen-ion concentration on the growth of strawberries in sand and in soil, C. S. Waltman. September, 1931.
322. Report on soil experiment fields, George Roberts and J. F. Freeman. September, 1931.
323. Some factors affecting the price of white burley tobacco, Dana G. Card. October, 1931.
324. An analysis of clover failure in Kentucky, E. N. Fergus. November, 1931.
325. Analyses of commercial fertilizers, H. E. Curtis, H. R. Allen and Lelah Gault. December, 1931.

Scientific Papers:

Effect of manganese, copper and zinc on the growth and metabolism of *Aspergillus flavus* and *Rhizopus nigricans*, J. S. McHargue and R. K. Calfee. The Botanical Gazette, v. 91, No. 2, pp. 183-193, 1931.

The mineral, nitrogen and fat content of some varieties of mature bean seed and string beans, J. S. McHargue and W. R. Roy. The Jour. of Nutrition, v. iii, No. 5, pp. 479-481, March, 1931.

Effect of manganese, copper and zinc on the growth of yeast, J. S. McHargue and R. K. Calfee. Plant Physiology, v. 6, p. 559, 1931.

The iron, manganese, copper, zinc and iodine content of some important forage crops, J. S. McHargue, W. R. Roy and J. G. Pelphrey. Read at meeting of Am. Chem. Society, Buffalo, 1931.

The effect of a diet of polished rice on the mineral content of the carcasses of pigeons, J. S. McHargue and W. R. Roy. Am. Jour. Physiology, v. 99, pp. 221-226, 1931.

A new method for the determination of iodine in soils, J. S. McHargue, D. W. Young and W. R. Roy. Read at meeting of Am. Chem. Society, Buffalo, 1931.

Miscellaneous fertilizers and soil amendments, J. S. McHargue. v. II, Chap. vii, pp. 432-473, Wiley's Principles and Practice of Agricultural Analysis. 3d edition, 1931.

Feeding to reduce production costs, E. S. Good. Proc. Second annual meeting Md. Stockman's Assoc., Jan. 7-8, 1931.

Some factors in livestock management, E. S. Good. Proc. Second annual meeting, Md. Stockman's Assoc., Jan. 7-8, 1931.

Progress report of strains of Bact. abortus Bang, each obtained from an individual organism, E. S. Good and Amanda Helen Harms. Read at annual meeting of Ky. Acad. Science, 1931.

Chemical control of battery-brooder-raised chickens, G. Davis Buckner, J. Holmes Martin and W. M. Insko, Jr. Read at annual meeting of Ky. Acad. Science, 1931.

Blackleg of tobacco seedlings, E. M. Johnson and W. D. Valleau. Phytopathology 21:973-978, Oct., 1931.

The viruses concerned in a natural epiphytotic of streak in tomatoes, W. D. Valleau and E. M. Johnson. Phytopathology 21: 1087-89, Nov. 1931.

Peach defoliation, cover crops and poison resistance, W. D. Valleau. Trans. Ky. Hort. Soc., p. 153. 1931.

Principles of peach scab control. Trans. Ky. Hort. Soc., p. 64, 1931.

A rapid colorimetric method for the determination of potassium by the use of sodium cobaltinitrite, E. M. Emmert. Jour. A. O. A. C., v. 14, No. 4, pp. 573-575, Nov. 15, 1931.

A colorimetric method for the determination of carbon dioxide, E. M. Emmert. Jour. A. O. A. C., v. 14, No. 3, pp. 386-389, Aug. 15, 1931.

A method of oxidizing and dissolving soil for the determination of total and filterable manganese and phosphorus, E M. Emmert. Soil Sci., v. 31, No. 3, pp. 175-182, March, 1931.

Thinning vs. tree vigor for peach size, A. J. Olney. Trans. Ky. State Hort. Soc., p. 50, 1931.

Effect of vitamin D factors on the hydrogen-ion concentration of the white and yolk of hens' eggs and on the percentages of ash, calcium, iron and inorganic phosphorus in the yolk, S. E. Erikson, R. E. Boyden, W. M. Insko, Jr., and J. Holmes Martin. Read at meeting Nat. Home Economics' Assoc., Detroit, Mich., June, 1931.

Corynebacterium equi, a factor in pneumonia of foals, W. W. Dimock and P. R. Edwards. Jour. Am. Vet. Med. Assoc., v. 17, p. 809, 1931.

ROBINSON SUBSTATION.

Meetings and Camps. Four meetings were held, including

the camp for farm women and homemakers, the camp for 4-H Club boys and girls, a meeting of county agricultural and home demonstration agents and club leaders, and the Robinson Harvest Festival. This was the sixth consecutive year for the holding of the Robinson Harvest Festival, which continues to grow in interest and appeal to the people of the eastern section of the state.

Forestry. A check was made of survival and average heights of plantings in different parts of the forest. A 1926 planting of black walnut in which half the plot was hoed annually, showed an average of 3' for the neglected portion and 5' 7" for the hoed portion. Black locust planted in several different "slips" showed an excellent growth with fair survival. Of the native species, shortleaf pine has made excellent growth. Of two 1926 plantings, one averages 7' 1" in height and the other 5' 7". Of the introduced species, slash, loblolly and Japanese red pine, all on bottom or near bottom land, have made most rapid growth. In three small plots, each averaged seven feet in height in four years. Red, white, Scotch and jack pine have done well. Norway spruce in three 6-year plantations averages 2' in height.

Orchard and Small Fruits. The peach and apple orchard made good growth during the season and bore an excellent crop. The performance of the orchard has attracted popular attention and interest thruout eastern Kentucky. Small fruits also continued to do well and the plantings at the Substation have served to stimulate planting in the community for home use and local market.

Grading Mountain Mongrel Hens. The project involving the use of Rhode Island Red and Ancona males in grading mountain mongrel stock was completed during the year. A summary of the four years' work shows that the $\frac{3}{4}$ and $\frac{7}{8}$ grades in both breeds laid practically as well during the winter and for the year as their corresponding purebred check pens. Altho slightly smaller, the Rhode Island Red grades ($\frac{7}{8}$ pure) closely resembled their purebred half-sisters in type and color. Also grading-up showed material improvement in egg size and

egg-shell color. The third generation grades laid mostly deep brown eggs whereas the mongrel great-grandams laid eggs of all shades from white to deep brown. The third generation of Ancona grades resembled their half-sisters quite closely in type and color, except that they showed less mottling (white tips to the feathers). There had also been a decided trend toward the white egg-shell color of the Ancona, as only three of the F₃ grade pullets laid tinted eggs.

While the mongrel check pen showed a gradual increase each year in winter and yearly egg production, it showed no tendency to increase in egg weight or uniformity of egg-shell color. The average egg weight actually decreased from 1.93 ounces for the foundation mongrels to 1.85 ounces for the third generation mongrels. One interesting point in the test was the steady improvement in average egg production of the mongrels. This improvement is undoubtedly due to both the improvement in environmental conditions (over those of the native mountain mongrels) and the obvious choice of mongrel males each year that contained an admixture of Leghorn and Minorca blood. Earlier hatching (which meant also that the January and February layers had more daughters to be tested in the subsequent generation) also played a part in this increase. The egg weight of the Anconas increased from 1.67 ounces for the foundation mongrels to 2 ounces for the 7/8 grades and the Rhode Island Reds from 1.89 ounces to 2 ounces for the corresponding generations. There was also a slight increase in average egg size of the purebred Rhode Island Reds and Ancona pullets. It is safe to conclude from the results of the test that grading-up will result in increased body weight when Rhode Island Red males are used and increased egg weight when Ancona or Rhode Island Red Males from dams with good egg size are used. By the continued use of purebred males egg-shell color can be steadily improved toward white for the Ancona grades and deep brown for Rhode Island grades.

WESTERN KENTUCKY SUBSTATION.

Soil Management. A soil management study is being made

on that part of the farm that lies on the Chester sandstone area. This area had been abandoned for cropping previous to its acquirement by the Experiment Station. The study, begun in 1929, includes various fertilizer tests, methods of application, and crops to which fertilizers are best applied. The rotation is corn, wheat and a mixture of legumes and grass for the third crop. Two crops of corn, two of wheat and one of hay have been grown. The average yields of crops for limestone and superphosphate and for adjoining check plots are:

	Check	LP
Corn	23.5 bus.	43.0 bus.
Wheat	2.9 bus.	14.5 bus.
Hay	1197.0 lbs.	3040.0 lbs.

Pasture Studies. The experimental pastures which have received no fertilizer treatment since 1927 were grazed with yearling grade Herefords. The beef production as a result of pasturing on each of these three 10-acre fields was: Field No. 1 (no treatment) 610 pounds; Field No. 2 (1,200 lbs. rock phosphate to the acre) 1,220 pounds; Field No. 3 (1½ tons limestone and 600 lbs. 16% superphosphate) 1,300 pounds. These three fields are significantly different in vegetation, altho each was sown with a mixture of lespedeza, sweet and white clover, orchard-grass, Kentucky and Canadian bluegrass seeds. Practically none of the original seedings, except lespedeza and a small amount of redtop, remain on Field No. 1; native plants make up most of the vegetation. Lespedeza, orchard-grass and redtop provide practically all the pasturage on Field No. 2. All sown species remain on Field No. 3, but the grasses are much more abundant than the legumes. In fact, except on the few comparatively bare areas, the legumes appear relatively unimportant. The bluegrasses are increasing at the expense of redtop over most of the field and in several places, the sod is almost pure Kentucky bluegrass. Persimmon and sassafras bushes of current year's growth made up a conspicuous portion

of the vegetation of Field No. 1, whereas they were almost negligible on Field No. 3. The approximate numbers of such bushes to the acre were 2,100, 1,200 and 90 in fields Nos. 1, 2, and 3, respectively.

Preferential grazing of beef cattle of a number of grasses indicates that orchard grass is much less palatable than other grasses used in pasture mixtures. Tall oatgrass, apparently the most palatable grass, is only slightly preferred to meadow fescue, perennial rye grass, Kentucky and Canadian bluegrass and sheep fescue.

Top dressing with various nitrogen carriers at the rate of 24 pounds of nitrogen to the acre greatly increased the pasturage, but was less profitable than limestone and phosphate, per dollar invested.

Legumes and Grasses. In the study of the effect on productiveness of different legumes and grasses as the third crop in a 3-year rotation with corn and wheat, the 3-year average yields of corn following some of these legumes were:

	Bushels
1. Check	38.6
2. Superphosphate, lespedeza turned under	46.2
3. Superphosphate, lespedeza for hay	41.0
4. Check	39.3
5. Limestone, superphosphate, lespedeza for hay	54.7
6. Superphosphate, cowpeas for hay	36.3
7. Check	44.9
8. Superphosphate, soybeans for hay	42.6
9. Superphosphate, soybeans for seed, straw returned	45.6
10. Check	44.6
11. Limestone, superphosphate, sweet clover—1st year for hay; 2d year for seed, straw returned	62.2
16. Check	41.5
17. Limestone, superphosphate, red and alsike clover for hay	62.1
18. Same, clover turned under	67.2
19. Check	47.1

Tobacco Studies. The fertilizer tests in the studies of fertilizers and rotations for tobacco, have already shown significant results. The rotation experiments are not old enough to have significance. The fertilizer tests are made in a 6-year rotation

consisting of tobacco, 2 years; wheat, 1 year; clover and grass, 3 years. Five hundred pounds of fertilizer of 3-10-7 analysis produced a 4-year average of 1,140 pounds of tobacco per acre, against 775 pounds on unfertilized soil. Land limed at the rate of 2 tons of ground limestone per acre in 1926 and treated with an average of 325 pounds of superphosphate per crop, and 10 tons of manure for each crop, produced 1,235 pounds of tobacco against 775 pounds on untreated land. A fertilizer with a high ratio of phosphoric acid and potash to nitrogen was used, in order that there might be a carry-over for the wheat and grass that follow the tobacco crop.

Liming Experiments. Some of the most interesting results on the Western Substation farm are the yields of hay obtained after light applications of limestone. In the liming experiment, made with a rotation of corn, wheat and mixed grasses and legumes, 1 ton and 2 tons of ground limestone were applied in 1926, when wheat was sown, and none has been applied since. At the same time, one-third of a ton of ground limestone of different fineness was applied to each of five plots, and the equivalent in hydrated lime to another plot. These small applications were repeated in 1929, when wheat was sown. A mixture of timothy, clover and lespedeza was sown in the spring of 1930. Because of drouth, the seeding perished except the lespedeza and a very thin stand of alfalfa. All the lime plots received a uniform treatment of superphosphate and potash. The average increase in hay yield over the check plots was 2,325 pounds per acre for the light applications, 1,987 pounds for the 2-ton application, and 1,380 pounds for the 1-ton application of limestone. The increase for superphosphate and potash without lime was 660 pounds per acre.

Selective Flock Breeding. A summary of the five years of breeding shows that altho the winter rate of egg production was distinctly improved during the past year in both the Barred Plymouth Rocks and White Leghorns, yet there was no significant increase in the yearly production of the latter breed. Each year the late-molting hens that showed physiological signs of high egg production were selected and mated to pedigreed

males out of hens with records over 200 (between 240 and 260 eggs for the Leghorns). The records of the pullets raised from these flock matings are given in the table.

AVERAGE EGG PRODUCTION

	Barred Plymouth Rocks		White Leghorns	
	Winter	Yearly	Winter	Yearly
1926-27	29	101*	41	153*
1927-28	35	142	39	181
1928-29	53	171*	51	182*
1929-30	41	152	42	183
1930-31	70	187	65	185

* 11 months.

It is interesting to note that this simple breeding program is equally effective with both the general-purpose and egg breed fowls.

Orchard and Small Fruits. The best growth and yield of peaches this year was made on plots which had been cultivated during the summer and sown to winter oats in late August, for winter cover. All apple trees made a remarkably uniform growth. The cultivation-and-cover-crop plots continued to make slightly more growth than the sod plots and the foliage had a better color. The 1931 strawberry crop was remarkably fine. This completed seven crops harvested from four different series of plots in this experiment. In spite of difficulties in obtaining satisfactory stands of plants in 1928 and 1929, on account of wet weather in the spring, and of the excessively dry weather in 1930 and 1931, the results have been invariably the same. The check plots that received no commercial fertilizer except the initial treatment of limestone and phosphate to establish the sweet clover which has been used in rotation with the strawberries, have produced far larger yields than any of those that received additional fertilizer treatments. The average yield of the check plots in 1931 was 159 crates per acre, which is about three times the average commercial yield.

Applications of sulfate of ammonia resulted in vigorous plant growth and relatively poor yields. Potassium depressed the yield sharply and superphosphate also depressed the yield. It is apparent that sweet clover in the rotation put the soil into excellent condition for strawberries and that the additional use of fertilizers was not only unnecessary but actually harmful. If the same response can be obtained on the soils in the strawberry section of western Kentucky, the average yield can be increased and the cost of production materially reduced.

FINANCIAL STATEMENT

In Account with the United States Appropriations, 1930-31.

	Hatch Fund	Adams Fund	Purnell Fund
Receipts:			
From the Treasurer of the United States, as per appro- priations for fiscal year ended June 30, 1931	\$15,000.00	\$15,000.00	\$60,000.00
Expenditures:			
By salaries	14,854.82	14,444.87	49,114.94
Labor			3,163.72
Stationery and office supplies..		11.89	64.05
Scientific supplies, consumable		113.12	697.52
Feeding stuffs		34.14	627.65
Sundry supplies		7.50	249.68
Fertilizers			1.20
Communication service			81.76
Travel expenses	83.58		3,566.90
Transportation of things			24.89
Publications	61.60		1,885.83
Heat, light, water and power..		21.73	24.12
Furniture, furnishings, fixtures			437.25
Library			25.09
Scientific equipment		284.25	14.40
Livestock		82.50	9.50
Tools, machinery and appliances			11.50
Total	\$15,000.00	\$15,000.00	\$60,000.00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Kentucky Agricultural Experiment Station for the fiscal year ended June 30, 1931; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was none on the Hatch Fund and none on the Adams Fund and none on the Purnell Fund; that the receipts for the year from the Treasurer of the United States were \$15,000.00 under the act of Congress of March 2, 1887, \$15,000.00 under the act of Congress of March 16, 1906, and \$60,000.00 under the act of Congress of February

24, 1925, and the corresponding disbursements \$15,000.00, \$15,000.00, and \$60,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balance of \$ none, \$ none, \$ none, respectively.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, March 16, 1906, and February 24, 1925, and in accordance with the terms of said acts, respectively.

Signed :

Seal of
Institution
Attest :

THOMAS COOPER,
D. H. PEAK,
WELLINGTON PATRICK,
Auditors.

JANE J. NICHOLS,
Custodian of the Seal.

METEOROLOGICAL SUMMARIES

Compiled from the Records of the U. S. Weather Bureau Station,
Lexington, Ky., for the Year 1931.

Month	Temperature, Degrees Fahrenheit							Relative Humidity, Percent 7 a. m.	Precipitation, in Inches				Percent of Sunshine
	Mean			Extreme					Total	Maximum in 24 Hours	Date	Total Snowfall, Inches	
	Maximum	Minimum	Monthly	Maximum	Date	Minimum	Date						
January	41.9	29.4	35.6	60	24	12	1	83	0.77	0.30	11-12	T	42
February	46.7	31.9	39.3	62	7	18	15	83	3.40	1.03	8-9	1.5	40
March	44.7	31.0	37.8	62	14	21	10	88	3.19	1.16	27	3.9	29
April	63.2	44.8	54.0	81	19	30	2	75	4.36	1.61	21-22	0.2	58
May	70.2	52.2	61.2	88	29	39	3	77	1.13	0.31	6-7	0	48
June	84.6	65.0	74.8	96	28	49	1	68	1.83	0.81	22-23	0	63
July	88.8	70.0	79.4	96	17	63	11	71	8.50	3.57	3-4	0	67
August	82.3	66.2	74.2	92	1	58	12	82	2.40	1.09	19-20	0	45
September	82.3	64.4	73.4	93	21	47	29	79	2.15	0.70	2-3	0	71
October	69.2	52.3	60.8	84	3	37	18	80	4.44	2.34	13-14	0	56
November	62.3	47.2	54.8	76	22	28	26	81	2.50	0.83	29-30	T	42
December	51.2	37.5	44.4	66	11	25	2	90	5.84	2.45	12-13	0	20
The Year	65.6	49.3	57.5	96	Jul 17	Jan 12	Jan 1	80	40.51	3.57	Jul 3-4	5.6	48

Wind					Number of Days											
Average Hourly Velocity	Prevailing Direction	Maximum For five min.			Gales, 33 miles per hour or over	Clear	Partly Cloudy	Cloudy	Precipitation of .01 inch or more	With trace or more of snow	Thunderstorms	Dense fog	Max. Temp.		Min. Temp.	
		Velocity	Direction	Date									90 deg. or above	Freezing or below	Freezing or below	Zero or below
11.6	SW	33	W	30	1	10	6	15	6	5	0	0	0	7	20	0
10.3	N	30	W	13	0	8	4	16	9	4	0	1	0	2	17	0
12.1	W	36	W	25	5	5	8	18	11	2	1	0	0	2	20	0
10.8	SW	30	NW	26	0	16	6	8	9	2	4	0	0	0	2	0
11.3	SW	35	SW	20	2	13	6	12	9	0	6	0	0	0	0	0
9.1	SW	39	NW	20	2	12	16	2	9	0	10	0	9	0	0	0
8.5	S	40	W	5	3	15	13	3	11	0	13	0	18	0	0	0
8.7	SW	29	NW	3	0	8	15	8	11	0	7	0	3	0	0	0
10.2	S	31	NW	25	0	20	6	4	8	0	4	0	9	0	0	0
10.9	SW	29	SW	27	0	17	3	11	12	0	3	1	0	0	0	0
11.7	SW	33	S	20	2	9	8	13	12	1	0	2	0	0	2	0
11.7	SW	35	SW	11	1	4	4	23	19	0	2	6	0	0	9	0
				Jul												
10.6	SW	40	W	5	16	137	95	133	126	20	50	10	39	11	70	0

MONTHLY AND ANNUAL MEAN TEMPERATURE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1872													
1873	29.5	35.4	41.7	52.8	65.5	73.8	75.0	74.1	67.4	53.4	36.8	26.6	
1874	36.0	38.2	43.6	46.3	66.0	77.2	78.0	75.3	70.8	56.6	45.0	38.4	54.0
1875	27.0	29.4	42.4	49.2	63.5	71.5	76.2	71.1	64.0	51.8	43.2	42.6	56.0
1876	41.2	38.6	40.9	52.5	64.8	71.8	77.0						52.7
1887													
1888	31.2	36.3	41.4	55.6	62.9	72.3	75.8	74.3	62.8	51.0	43.8	35.2	
1889	37.4	31.6	45.8	55.0	62.8	69.2	75.4	72.1	65.4	52.3	43.0	50.2	54.0
1890	44.0	45.1	38.6	55.7	63.3	76.6	75.8	71.3	66.8	56.3	48.6	36.8	55.0
1891	37.1	41.1	40.4	57.3	61.5	75.8	72.8	72.8	71.7	55.4	43.2	42.9	56.6
1892	27.6	41.2	38.8	53.7	62.8	75.8	75.0	74.8	68.4	57.1	41.4	32.9	54.1
1893	23.1	36.5	43.2	56.7	61.2	72.4	78.6	74.0	70.2	57.3	42.8	37.0	54.4
1894	38.0	34.0	49.2	53.9	62.3	74.6	75.6	76.0	71.0	57.6	41.3	37.4	55.9
1895	27.7	23.4	42.7	55.8	62.3	75.4	73.4	75.8	72.8	52.3	45.0	37.4	53.7
1896	34.4	35.2	37.7	61.7	71.0	72.0	75.4	75.2	67.4	54.4	47.6	38.4	55.9
1897	30.0	37.4	47.6	53.3	59.4	72.0	75.7	73.8	72.4	63.9	46.4	36.8	55.7
1898	38.1	36.0	49.0	50.5	65.4	74.4	76.2	75.8	72.0	56.0	43.0	33.2	55.8
1899	33.8	24.4	42.1	55.8	66.7	74.6	77.2	77.0	67.6	60.6	48.2	33.4	55.1
1900	35.9	31.1	39.2	55.0	65.6	72.5	77.0	79.3	73.2	64.9	45.0	37.2	56.3
1901	34.2	29.4	43.8	49.0	62.8	73.9	80.3	74.0	67.0	57.9	40.2	31.2	53.6
1902	32.3	25.0	44.7	52.6	68.2	71.2	76.8	73.8	67.0	59.0	52.6	34.2	54.8
1903	32.1	35.6	50.4	53.4	67.7	67.7	76.6	74.4	69.8	56.9	40.0	28.5	54.4
1904	29.6	31.2	45.6	47.8	63.8	71.8	73.9	74.2	69.4	57.0	44.2	34.0	53.5
1905	24.4	24.9	49.2	53.8	65.8	72.3	74.6	73.6	68.4	55.4	43.7	35.3	53.5
1906	37.4	31.9	35.8	56.6	64.2	71.8	73.6	75.8	70.6	54.7	45.2	36.4	54.5
1907	40.4	32.4	51.5	45.3	59.1	68.6	75.5	72.8	68.0	53.4	42.2	36.7	53.8
1908	33.0	33.2	49.6	54.7	64.8	71.8	76.0	74.6	71.8	57.6	47.8	37.8	56.1
1909	37.2	41.0	42.6	53.9	61.8	72.8	72.7	74.5	65.6	52.8	53.0	27.8	54.6
1910	32.0	31.4	54.4	54.1	59.1	68.8	74.8	72.6	69.6	59.6	39.6	28.6	53.7
1911	38.3	40.4	42.9	51.6	69.5	73.8	75.6	75.8	72.5	58.2	39.8	40.8	56.6
1912	23.2	27.6	39.3	56.6	64.8	69.2	75.3	72.2	69.6	59.0	44.5	35.8	53.1
1913	41.6	32.8	44.4	53.2	64.9	73.4	78.2	76.7	68.9	56.5	49.4	38.0	56.5
1914	37.2	29.3	39.6	53.7	65.8	75.8	77.6	74.8	66.8	58.9	45.7	30.4	54.6
1915	32.0	39.8	35.8	59.2	62.4	70.2	74.5	69.5	69.5	59.8	48.8	35.9	54.8
1916	39.7	32.8	41.2	52.4	67.0	69.0	78.0	76.0	66.7	57.6	47.4	34.0	55.2
1917	35.2	31.8	44.2	53.8	56.9	70.0	74.5	74.4	67.2	50.0	44.0	25.3	52.3
1918	19.8	37.9	49.2	51.8	69.4	72.2	72.6	79.4	62.4	61.1	44.2	42.8	55.2
1919	36.9	36.0	45.6	54.3	62.2	76.4	78.8	73.5	71.5	64.0	44.9	31.2	56.3
1920	30.1	32.6	44.9	49.7	62.4	71.3	74.4	72.2	69.9	62.1	43.3	26.2	54.1
1921	37.4	38.2	54.6	57.5	64.9	76.2	80.2	74.6	73.2	56.8	48.0	38.9	58.4
1922	32.6	38.2	46.8	57.0	68.4	74.6	75.8	74.7	72.6	61.0	47.2	39.1	57.3
1923	39.1	31.6	42.6	53.3	63.0	74.0	76.6	74.4	69.0	56.2	44.8	45.2	55.8
1924	29.5	33.4	39.1	54.9	58.2	73.0	73.2	75.1	63.7	62.4	45.0	34.0	53.5
1925	32.8	43.0	46.6	59.2	59.8	75.8	75.0	76.2	76.2	50.2	43.2	31.8	55.8
1926	32.0	37.3	36.7	48.8	64.6	69.4	76.8	76.0	71.6	57.2	40.8	35.0	53.8
1927	33.4	43.4	47.7	55.4	63.4	68.8	75.3	69.5	72.2	61.1	49.6	35.0	56.2
1928	32.6	35.5	42.1	50.6	62.2	67.2	75.8	75.2	64.2	61.0	44.9	39.4	54.2
1929	31.9	29.2	49.4	57.8	62.2	70.6	75.0	72.4	68.2	55.1	41.8	36.2	54.2
1930	32.6	43.8	40.8	57.6	65.4	72.8	79.6	76.2	71.2	54.7	45.6	32.2	56.0
1931	35.6	38.2	37.8	54.6	61.2	74.8	79.4	74.2	73.4	60.8	54.8	44.4	57.5
Ave.	33.5	34.7	43.8	53.8	63.8	72.5	76.9	74.4	69.4	57.2	44.8	36.0	55.0

MONTHLY AND ANNUAL PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1872													
1873	2.53	4.05	3.73	2.89	6.05	4.49	3.37	2.94	1.60	5.47	1.21	3.30	
1874	5.41	4.89	5.90	6.81	0.79	3.55	6.26	1.57	2.89	0.92	4.27	3.83	43.52
1875	2.61	3.12	6.18	2.06	2.43	4.16	11.24	0.62	1.72	2.37	5.87	3.68	47.09
1876	6.06	1.66	3.63	4.20	2.16	4.13	3.84						46.06
1887													
1888	4.39	2.93	5.82	3.17	3.29	2.97	4.21	8.76	1.22	3.02	5.15	2.71	
1889	5.66	1.78	1.63	1.52	3.53	3.49	5.82	1.15	6.79	3.06	5.34	1.73	46.81
1890	5.34	8.13	9.91	3.59	4.71	7.43	3.14	7.32	1.82	2.38	3.54	4.05	41.50
1891	4.70	4.36	7.63	1.85	1.17	5.33	3.23	6.48	1.26	1.33	5.35	2.82	61.36
1892	2.35	3.10	4.01	6.57	5.32	3.81	6.22	3.28	4.10	0.45	3.72	3.03	45.51
1893	2.10	4.44	3.30	5.81	3.88	4.24	3.11	1.86	2.25	5.49	3.36	2.61	45.96
1894	3.58	3.35	2.13	4.19	3.81	4.44	0.87	3.67	4.05	1.50	1.38	3.45	42.55
1895	5.60	0.52	2.79	3.17	4.05	2.93	5.07	1.56	0.33	1.28	2.52	5.50	36.32
1896	1.25	3.15	5.41	0.40	3.20	3.74	0.39	3.37	4.25	1.27	4.30	2.56	43.29
1897	2.59	6.33	6.55	5.80	4.48	4.77	4.34	3.21	0.80	0.38	4.83	5.11	49.19
1898	9.56	2.20	8.18	3.29	6.13	7.94	5.72	2.99	3.55	5.27	2.89	2.80	60.52
1899	6.69	2.84	8.61	2.16	3.63	2.55	0.97	4.18	1.90	2.09	1.70	2.92	40.24
1900	2.13	3.17	1.98	1.23	3.54	2.19	2.80	5.75	1.85	0.79	6.38	1.86	33.67
1901	1.49	0.62	2.23	4.52	2.67	3.70	2.61	3.74	2.18	1.33	1.73	3.50	30.32
1902	4.77	0.90	2.92	1.27	2.43	5.19	2.33	1.89	2.60	2.11	3.09	6.60	36.10
1903	1.68	6.16	3.24	3.29	1.75	2.71	2.62	1.49	0.81	2.12	2.84	1.99	30.70
1904	1.92	2.38	4.75	3.08	2.60	2.51	3.13	2.44	1.71	0.57	0.53	3.10	28.72
1905	2.04	2.13	5.87	2.87	5.54	3.31	4.94	4.11	3.20	3.45	3.58	4.13	45.17
1906	2.29	1.84	6.45	1.11	3.15	4.68	3.89	4.92	5.03	0.74	3.95	4.54	42.59
1907	9.06	1.89	4.13	1.83	3.89	3.65	4.42	2.07	2.72	2.76	2.67	2.28	41.37
1908	1.85	4.81	8.17	4.99	4.20	2.42	3.60	2.98	0.38	0.72	1.65	2.13	37.60
1909	3.35	6.86	3.97	6.72	4.15	5.41	5.98	1.26	4.88	2.05	1.96	2.77	49.36
1910	4.46	4.11	0.46	4.22	6.24	5.92	7.66	4.15	7.92	1.67	1.72	2.81	51.34
1911	2.44	2.21	2.31	4.46	1.07	3.01	0.92	2.84	4.37	3.67	3.84	6.20	37.34
1912	1.78	2.50	4.36	6.89	5.11	2.15	4.70	3.23	2.09	0.51	1.02	3.66	38.00
1913	10.35	2.61	6.04	2.41	4.32	3.29	2.43	1.00	1.76	3.40	4.00	2.74	44.35
1914	2.50	3.87	2.24	2.23	1.65	4.77	2.63	4.69	1.82	5.32	1.62	4.40	37.74
1915	4.38	1.12	1.49	0.65	7.23	3.20	5.72	6.03	3.74	0.81	3.90	6.67	44.94
1916	5.65	3.40	3.30	1.01	2.92	5.33	1.72	2.34	2.75	2.04	1.25	3.63	35.34
1917	5.67	2.12	5.48	3.97	3.51	3.54	2.80	1.94	2.46	2.36	1.03	1.97	36.85
1918	4.46	1.92	1.55	2.09	4.13	3.61	2.01	2.68	1.41	4.57	2.24	4.83	35.50
1919	2.48	1.61	3.71	3.51	6.38	4.49	2.28	2.39	1.12	7.95	8.50	6.70	51.12
1920	5.26	2.11	4.62	6.42	2.51	2.39	1.73	6.71	4.88	2.75	2.22	1.40	43.00
1921	3.24	2.62	5.06	3.28	1.60	2.16	1.04	3.88	5.10	2.46	6.89	5.74	43.07
1922	1.87	3.12	7.75	4.46	3.10	2.44	2.13	2.20	5.99	1.25	0.88	5.67	40.86
1923	6.63	4.40	4.65	5.43	1.66	3.55	5.01	4.02	1.51	0.56	2.71	6.50	46.63
1924	5.00	2.60	2.42	3.75	3.04	4.04	2.77	2.28	3.89	0.11	1.32	5.59	36.81
1925	3.41	3.02	3.45	2.49	3.56	3.96	3.63	1.15	1.70	5.83	4.52	0.80	37.52
1926	4.43	2.27	2.52	1.54	2.06	2.78	5.95	7.03	4.04	7.46	3.21	4.32	47.61
1927	6.53	1.87	5.17	3.89	5.76	2.14	2.95	2.09	2.29	1.65	4.88	3.64	42.86
1928	2.68	2.30	2.67	2.79	2.12	10.62	5.16	4.30	0.71	2.69	3.79	1.92	41.75
1929	2.83	3.37	3.67	2.99	5.59	4.25	4.12	1.42	4.35	2.99	3.92	1.88	41.45
1930	4.44	2.91	2.54	0.81	3.35	1.89	0.45	1.69	2.80	0.63	1.59	1.79	24.89
1931	0.77	3.40	3.19	4.36	1.13	1.83	8.50	2.40	2.15	4.44	2.50	5.84	40.51
Ave.	4.00	3.06	4.33	3.38	3.55	3.89	3.97	3.28	2.82	2.51	3.19	3.63	40.84

EXTREMES OF PRECIPITATION AND WIND

Month	PRECIPITATION			WIND			
	Greatest in 24 Hours	Year	Day	Max. Vel. †	Dir.	Year	Day
January	3.50	1913	11	52	w	1928	24
February	3.04	1909	23-24	49	sw	1890*	25
March	3.61	1913	25-26	55	sw	1919	17
April	3.24	1909	29-30	52	sw	1909*	29
May	2.61	1898	6-7	52	sw	1924	24
June	5.50	1928	28-29	49	n	1890*	29
July	4.02	1875	11-12	52	nw	1929	1
August	2.98	1915	1-2	58	s	1918	6
September	5.45	1922	3	55	w	1899	14
October	2.34	1931	13-14	41	nw	1904*	21
November	3.95	1919	25-26	56	nw	1929	27
December	3.63	1919	6	49	sw	1895*	26

* Also in subsequent years.

† Basis of 3-cup anemometer.

EXTREMES OF TEMPERATURE

Month	Highest	Year	Day	Lowest	Year	Day
January	72	1929	18	-14	1918	12
February	75	1918	28	-29	1899	13
March	86	1929	25	-1	1873	4
April	90	1925	24	15	1875	18
May	93	1911	28	30	1876	1
June	99	1914	27	40	1910	3
July	104	1930	28	51	1891	9
August	100	1918	6	46	1915	31
September	95	1925	9	32	1899	30
October	89	1919	2	21	1925	29
November	78	1895	7	-3	1929	30
December	71	1875	31	-9	1917	10

